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To

CARL EMIL SEASHORE

PSYCHOLOGIST, DEAN OF GRADUATE STUDY, EXPLORER IN THE REALM OF MUSIC, MAN OF SCIENCE

IN COMMEMORATION OF THE COMPLETION OF THIRTY

YEARS OF DISTINGUISHED SERVICE TO

PSYCHOLOGY

AND TO

THE STATE UNIVERSITY OF IOWA

THIS VOLUME IS AFFECTIONATELY DEDICATED

BY FORMER STUDENTS

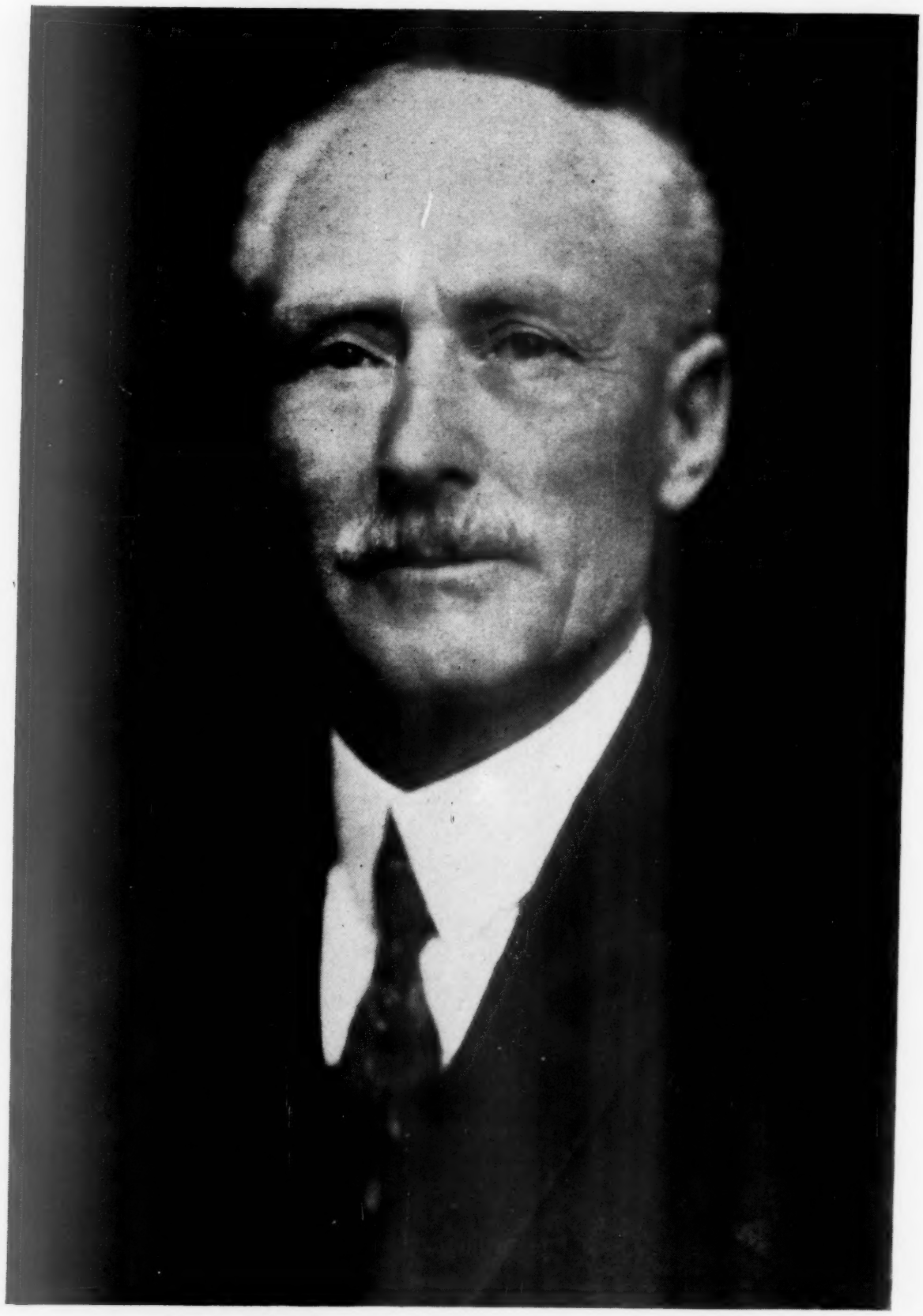
PREFATORY NOTE

This is a special number of the University of Iowa Studies in Psychology and is issued in honor of Dean Carl Emil Seashore. It commemorates his thirty years of service to Psychology and to this department in the University of Iowa and his twenty years of service as Dean of the Graduate College. The Editor of the Iowa Studies is now Professor Christian A. Ruckmick who has cordially coöperated in the present undertaking. The editing of the present number has been entirely in the hands of former students of Professor Seashore and all of the papers have been contributed by members of this group.

In addition to this special volume of studies a portrait painted by Mildred W. Pelzer of Iowa City has been presented to Dean Seashore by his students and will be hung at the University, and a collection of letters from former students has been assembled and presented.

THE EDITORS.

TABLE OF CONTENTS



Dear Carl E. Seashore

This telephotograph was printed from the unretouched negative received July 23, 1925 at New York City from Chicago over a telephone circuit 931 miles in length. The time required for transmission was 7½ minutes.

J. B. Kelly
Vice President
American Telephone & Telegraph Co.

195 Broadway
New York City

CARL EMIL SEASHORE — OUR DEAN [1]

Dean Seashore, head of the Graduate College of the University of Iowa, has been an active leader in the development of psychology, his chosen science. From the early day when he was instrumental in the introduction of the first laboratory course in psychology at Yale he has been a leader in the advancement of many branches of scientific work. He has held all of the positions of honor that professional psychology has offered in this country, and at the same time has been productive in scholarship. His publications include more than a hundred periodical contributions to theoretical and experimental psychology, several standard textbooks and almost a score of careful monographs in his special research field.

Dr. Seashore is now in his thirtieth year of service in the University of Iowa. Starting as assistant professor in psychology in 1897, he became successively full professor, head of the department, and in addition in 1908 dean of the Graduate College. His influence in the development of the educational policy of the University has been great. "Among other new educational ideas, Dean Seashore has sponsored the introduction of college entrance tests, placement examinations in the freshman class, sectioning of classes on the basis of ability, development of a system for sponsoring and interviewing gifted students." Through his research he has become recognized within and without the University as a consultant authority in special problems of music, graphic and plastic arts, engineering, medicine, and education, while maintaining interest and achieving high place as specialist in the psychological field of hearing. In years of service Dean Seashore is the oldest dean of a graduate school. His progressive program has placed the Graduate College of the University of Iowa in the forefront as a seat of research and advanced training.

For the last four years Dr. Seashore has added to his other duties those of field representative of the National Research

[1] Excerpts from a short article of appreciation in *University of Iowa News Bulletin,* October, 1926.

Council in the gifted student project. In this mission he has visited more than a hundred of the leading institutions of higher learning, consulting with their faculties and developing interest in the special and adequate education of the ablest university students.

Dr. Seashore belongs to that noteworthy group of scientists who are the gift to America from other lands. Born in Morlunda, Sweden, in 1866, he came as a boy to America with his parents who established themselves on a farm near Dayton, Iowa. Here young Seashore as a youth naturally thought first of becoming a farmer, but soon embarking on a scholarly career, he determined to specialize in psychology. In 1891 he graduated from Gustavus Adolphus College, having helped to earn his way as organist and director of a chorus by the gift of music that was later to combine with his scientific interest. He continued his scientific studies at Yale and secured the Ph.D. degree there in 1895. Thereafter he spent two years in the Yale laboratory, removing to Iowa in 1897. His progress at Iowa to a position of authority in psychology and to the deanship was rapid. His membership in the National Academy of Science testifies to the standing which he has achieved in the wide realm of scientific research in America.

Those who have been Dr. Seashore's students, and have conducted research under his direction, have known of his worth to the University and to the world of science. They have experienced in even a more vivid manner his personal strength and greatness. It has been their happy lot to know Seashore as teacher-friend, as one who could laugh buoyantly, who could transcend huge difficulties, one who was ever alive to all the concerns of life. Having this Seashore-experience was to have something ever to cherish in memory. A group of his students who have known and admired him in this personal and intimate way have desired to bring together this collection of their papers to form a volume of Iowa Studies in Psychology in honor of their teacher and comrade.

A COMPLETE ANNOTATED BIBLIOGRAPHY OF THE WRITINGS OF CARL EMIL SEASHORE[1]

BY

J. E. BATHURST AND R. D. SINCLAIR

INTRODUCTION

At the beginning of his career Dr. Seashore was interested primarily in accuracy of measurements, and he applied this interest to the study of visual illusions, which was practically a virgin field at that time. As a result of these efforts, fifteen years ago he finished the factual parts of a book, "Normal Illusions of Visual Space." This work still remains unpublished, partly because the author could not get a thoroughgoing theory of illusions and in part because of his change in interests. His last efforts in this field were directed to making, what he believes to be, a correct interpretation of data on "Illusions of Attraction of Regard." This article also remains unpublished.

His next interest, which was in the acoustic field, began about twenty-eight years ago in the study of pitch discrimination. There were two stages of development in this work: (1) the testing program, and (2) the study of the expression of emotion in music. During the former period the well known Seashore Music Tests were devised together with various other aspects of the testing program. The latter period was given to developing a technique for the measurement of the expression of emotion in music. The application of that technique is now going on.

The testing program in music was in full progress when the war came. The fact that Dr. Seashore had measured talent of any kind gave him the responsible position during the war of selecting senior students for training in specific fields. During and following the war work an intensive study of the individual was made. This was fundamental in the development of his present position in reference to the individual student and higher

[1] Complete up to 1926.

education. His new book entitled *The Student in Higher Education* is the culmination of his contributions in this field.

A study of the writings of Dr. Seashore reveals a change in style and in his method of handling scientific data. During the early part of his career his writing was "choppy" and he was afraid of generalizations. Later, especially noticeable in his works on the psychology of musical talent, we find generalizations relative to the meaning of the data appearing. At present, practically all of his writings are generalizations. A closer inspection of his works impresses one with the fertility of his ideas, the receptivity to facts and the richness of viewpoint which characterize his mind.

1. *On Monocular Accommodation-Time.* Stud. Yale Psychol. Lab., 1893, I, 56–70.

The relaxation-time is greater than the accommodation-time, *i.e.,* it takes longer to accommodate from near to far than from far to near. This conclusion differed widely from conclusions made by previous experimenters.

2. *Measurements of Illusions and Hallucinations in Normal Life.* Stud. Yale Psychol. Lab., 1895, III, 1–67.

Doctor's dissertation. Illusions of weight were studied by laboratory methods and it was found that these illusions follow definite laws. It is suggested that if the laws are known allowance may be made for the errors of perception.

3. *Influences of the Rate of Change upon the Perception of Differences in Pressure and Weight.* Stud. Yale Psychol. Lab., 1896, IV, 1–35.

It was found that in stating the sensitiveness reference must be made to the following factors: the special sense organ, the kind of threshold, the standard stimulus, the direction of change, method of marking the beginning and the end of the change, and knowledge of the facts.

4. *Weber's Law in Illusions.* Stud. Yale Psychol. Lab., 1896, IV, 62–68.

Deals with the illusion of weight, the problem being whether

Weber's law depends upon the so-called real intensity or upon the apparent intensity of the stimulus. The results indicate the latter.

5. *A New Factor in Weber's Law.* Psychol. Rev., 1897, IV, 522–524.

On the question whether Weber's law depends upon the real or apparent stimulus. Concludes for the apparent stimulus.

6. *New Psychological Apparatus.* Univ. of Iowa Stud. in Psychol., 1899, II, 153–163.

A description of the Seashore Spark Chronoscope and of an Audiometer. The need and significance of each piece of apparatus is discussed.

7. *Hearing Ability and Discriminative Sensibility for Pitch.* Univ. of Iowa Stud. in Psychol., 1899, II, 55–63.

Results for children and university students.

8. *Motor Ability, Reaction-time, Rhythm, and Time-sense.* Univ. of Iowa Stud. in Psychol., 1899, II, 64–84.

A statistical study of the time of mental processes. The following items were investigated: (1) time of simple reaction, discrimination, and choice, (2) time of true rhythm in action, and (3) time of regulated rhythm in action.

9. *Localization of Sound in the Median Plane.* Univ. of Iowa Stud. in Psychol., 1899, II, 46–54.

Determination of the constant tendencies in the localization of sound. The experiments support the theory that we normally expect sounds to come from "up front" more than from any other direction. Localization was influenced also by the intensity of the sound.

10. *Visual Perception of Interrupted Linear Distances.* Univ. of Iowa Stud. in Psychol., 1899, II, 1–35.

A study of the extent and the nature of some of the variations of the Müller-Lyer illusion for untrained observers.

11. *The Material-Weight Illusion.* Univ. of Iowa Stud. in Psychol., 1899, II, 36–45.

Verification of the existence of a negative illusion of weight due to the appearance of the material in the object lifted.

12. *An Illusion of Length.* Psychol. Rev., 1900, VII, 592–599; and Univ. of Iowa Stud. in Psychol., 1902, III, 29–37. (With Mabel Clare Williams.)

On the cause of the illusion of length. Eye-movement was considered one of the primary factors. The amount of illusion did not vary with the length of line.

13. *Suggestions for Tests on School Children.* Educ. Rev., 1901, XXII, 69–82.

The results of a series of tests which were devised to determine some of the most important individual needs and conditions of children in school. The tests were based on approved laboratory techniques, and were adapted for being applied by teachers.

14. *A Method of Measuring Mental Work: the Psychergograph.* Univ. of Iowa Stud. in Psychol., 1902, III, 1–17.

A presentation of the needs, possibilities, and significance of the problem; a description of the apparatus devised and an analysis of the problem in terms of the apparatus to be used.

15. *A Voice Tonoscope.* Univ. of Iowa Stud. in Psychol., 1902, III, 18–28.

Description of an instrument for measuring the pitch of tones produced by the human voice.

16. *The Localization of Sound.* Middletonian, 1903, IV, 18–32.

Discussion of the nature of a psychological experiment, illustrated by the problem of sound localization in the median plane and in the horizontal plane.

17. *A Sound Perimeter.* Psychol. Rev., 1903, X, 64–68.

A presentation of the shortcomings in the investigations of auditory space perception, and a description of an apparatus devised by the author which would make it possible to control conditions thereby avoiding these errors.

18. *Experimental Study of Mental Fatigue.* Psychol. Bull., 1904, I, 40–41.

Brief outline of an article which was to appear in an early issue of the Psychological Review. He enumerates the ideas which must be abolished in the experimental study of mental fatigue, and points out the legitimate and promising lines of progress.

19. *The Experimental Study of Mental Fatigue.* Psychol. Bull., 1904, I, 97–101.

Read before the American Psychological Association in 1903. This paper deals with (1) some errors and (2) some lines of progress in the experimental study of mental fatigue. The author discourages applying large generalizations for immediate practical purposes. He considers the means not yet sufficient.

20. *Periodicity and Progressive Change in Continuous Mental Work.* Univ. of Iowa Stud. in Psychol., 1905, IV, 47–101; Psychol. Monog., 1905, VI (No. 28), 47–101. (With G. H. Kent.)

Deals with sensibility, discrimination, and memory. Fatigue was the primary object of interest and search. Constant progressive change was not found.

21. *Die Aufmerksamkeitsschwankungen.* Zeit. f. Psychol. u. Physiol. d. Sinn., 1905, XXXIX, 448–450.

A brief criticism of Herr Bertil Hammer's (Zeit. f. Psychol. u. Physiol. d. Sinn., XXXVII, 363–376) explanation of the fluctuations of attention, based on two series of experiments, one in vision and the other in hearing.

22. *The Tonoscope and Its Use in the Training of the Voice.* The Musician, 1906, XI, 331–332.

Presents the fact that the physiological limit of the ear is the limit of accuracy of control in singing, and that present methods of training the voice seldom if ever reach such a limit of accuracy. The tonoscope is applicable to this.

23. *The Spark Chronoscope.* Science, 1907, XXVI, 512–514.

A detailed description of the spark chronoscope, pointing out its general field of usefulness.

24. *Introduction to the Second Annual Course of Public Lectures on Practical Ethics.* Dept. of Philos. and Psychol., Univ. of Iowa, 1906, 1–7.

The relation of ethics to health and to the aim of life is briefly discussed.

25. *The Effect of Practice on Normal Illusions.* Univ. of Iowa Stud. in Psychol., 1908, V, 103–148; Psychol. Monog., 1908, IX (No. 38), 103–148.

This study involves (1) The Illusions in the Length of a Cylinder by E. A. Carter, (2) The T-Illusion, E. C. Farnum, (3) The Muller-Lyer Illusion, E. C. Farnum, and (4) The Illusion of Distance between Circles, R. W. Sies. These experiments are reviewed by Dr. Seashore. They show a number of factors which determine what effect practice has upon normal illusions.

26. *Elementary Experiments in Psychology.* Holt & Co., N. Y., 1908, 218 pp.

A manual for a first course in psychology which requires no laboratory facilities.

27. *Some Aspects of Graduate Work.* Iowa Alumnus, March, 1909.

A setting forth of the development and growth of the graduate schools in the state universities.

28. *Is Taste a Special Sense?* Psychol. Bull., 1909, VI, 151.

Describing a crucial experiment to answer the question and answering it in the affirmative.

29. *Homogeneous Content in the Measurement of Continuous Memory Processes.* Psychol. Bull., 1909, VI, 217–222.

A presentation of the status of experimental pedagogy; its relation to experimental psychology; a method of using homogeneous sensory stimuli relative to the measurement of memory processes;

an analysis of such processes, and the merits of such a method or plan.

30. *General Report on the Teaching of the Elementary Course in Psychology: Recommendations.* Psychol. Monog., 1909–1910, XII (No. 5), 80–91.

A summary of the Report of the Committee of the American Psychological Association on the Teaching of Psychology, of which Dr. Seashore was chairman.

31. *The Class Experiment.* J. of Educ. Psychol., 1910, I, 25–30.

A presentation of various methods of teaching psychology by experiment, viz., (1) the regular technical laboratory course, (2) the exhibition experiment before the class, (3) the individual experiment without apparatus, and (4) the class experiment. An elaboration is made of the value and significance of the last method.

32. *Measurement of Pitch Discrimination: a Preliminary Report.* Psychol. Monog., 1910–1911, XIII (No. 53), 21–63.

Read before the American Psychological Association. Written to correct the inadequacies of various methods and to provide recommendations in regard to the proper technique for this measurement.

33. *The Mid-Day Nap.* J. Educ. Psychol., 1910, I, 293–295.

Advocating to " cut short the long, light sleep of the late morning hours and substitute a short sleep at some favorable time during the working day." The argument is based on Kohlschutter's experiments.

34. *Training the Voice by the Aid of the Eye in Singing.* J. Educ. Psychol., 1910, I, 311–320. (With E. A. Jenner.)

Considers the question whether development in the control of the pitch of the voice can be facilitated by using the tonoscope. Answers in the affirmative with data to support conclusions.

35. *Graduate Study.* Bull. Univ. of Iowa, June 2, 1910 (New Series No. 11).

An address delivered to students in the colleges of Iowa in

1909. The chief points are that graduate study is new in this country, that it means research, begins after college, is expensive to the institution, is practical, is farsighted, and that it stands for liberal culture.

36. *The Play Impulse and Attitude in Religion.* Amer. J. Theol., 1910, XIV, 505–520.

A review of the salient characteristics of play, and the relationship of these to the religious life. Play is defined as "self-expression for the pleasure of expression."

37. *The Consulting Psychologist.* Pop. Sci. Mon., 1911, LXXVIII, 283–290.

A convincing article showing the need, the field, and the practicability for the employment of a "consulting psychologist." Four large divisions are discussed: (1) mental pathology, (2) education, (3) technical arts, crafts, and professions, and (4) eugenics.

38. *The Measure of a Singer.* Science, 1912, XXXV, 201–212.

Presidential Address before American Psychological Association. The nature and significance of applied psychology in the field of music is discussed.

39. *Apparatus.* Psychol. Bull., 1912, IX, 235.

Remarks on Crehore and Meara's description of the micrograph, Dunlap's description of the fall hammer, chronoscope, and chronograph, and Ponzo's description of a two-point aesthesiometer.

40. *Apparatus.* Psychol. Bull., 1913, X, 32–34.

Concerning sound localization apparatus, rhythm interruptor, rhythm-box controller, rhythm hammer, and automatic tuning-fork.

41. *Apparatus.* Psychol. Bull., 1914, XI, 19–21.

Description of apparatus used by Russel, Austin, Jackson, Hurthle, Schackwitz, Wirth and Dunlap, Wohlgemuth, Luckiesh, and Urban.

42. *Psychology in Daily Life.* D. Appleton, N. Y. and London, 1914. xvii+226 pp.

A contribution to The Conduct of Mind Series. The aim of this book is to apply psychology to the problems of living—economic, hygienic, pedagogical, ethical, aesthetic, and religious problems. There are chapter headings of Play, Serviceable Memory, Mental Efficiency, Mental Health, Mental Law, Law in Illusion, and Mental Measurement. The book is written in semi-technical style.

43. *The Tonoscope.* Univ. of Iowa Stud. in Psychol., 1914, VI, 1–12; Psychol. Monog., 1914, XVI (No. 69), 1–12.

A description of a new model of the tonoscope. Aside from being used in direct voice study this instrument may be used to transcribe speech or musical records from the phonograph or any other recording instrument.

44. *The Measurement of Musical Talent.* Musical Quar., 1915, I, 129–148.

Deals with the psychology of individual talent and classifies the principal measurable musical traits. Shows how data resulting from the tests may be reduced to a "common denominator" or norm and suggests the meaning and use of such a procedure and the results obtained.

45. *Apparatus.* Psychol. Bull., 1915, XII, 29–30.

Review of a practical electric perimeter, an aesthesiometer, an aurometer, an apparatus for association timing, an Enthoven galvanometer, and an apparatus for use of spectral colors.

46. *Plans and Possibilities of a Research Station for the Conservation and Development of the Normal Child.* The Alumnus, 1915, XII, 16–17.

A condensed outline of the organization and character of such work, as prepared by a committee on child welfare in the State University of Iowa. Stresses the aim of securing specialists in specific fields of child welfare research and the importance of a scientific study of the child.

47. *The Psychogram in Vocational Guidance.* Proc. Iowa Acad. Sci., 1915, XXII, 341–342.

A description of the Psychogram, a single graphic curve showing the specific character of individual talents in quantitative terms as compared with the standardized or normal distribution of such talents. All cases are arranged and shown in percentile rank.

48. *A Child Welfare Research Station.* Bull. Univ. of Iowa, January 15, 1916 (New Series No. 107).

A concrete presentation of the child welfare problem and of the principal fields of activity of the Child Welfare Research Station at the State University of Iowa. The work for the conservation of child life is divided into six divisions: (1) heredity and parental care, (2) nutrition of the child, (3) preventive medicine, (4) school surveys and school policy, (5) education and morals, and (6) applied psychology.

49. *Scientific Procedure in the Discovery of Musical Talent in the Public Schools.* The Music Superv. Jour., 1916, II, 10–11.

A survey of what is being done in the laboratory in the way of discovering a technique and a procedure.

50. *Elemental Tests in Psychology.* J. Educ. Psychol., 1916, VII, 81–87.

The results of elemental tests given to fifteen blind and fifteen seeing persons. The thresholds of sensory discrimination in each of the six measurements was about the same for the seeing as for the non-seeing groups.

51. *Mentality Tests.* J. Educ. Psychol., 1916, VII, 163–166.

A presentation of the status, development, and future outlook of mental testing and an outline of the outstanding problems for consideration.

52. *Mentality Tests: A Symposium.* J. Educ. Psychol., 1916, VII, 229–241.

Deals with the opinions of a list of leaders in the field of mental testing.

53. *Seeing Yourself Sing.* Science, 1916, XLIII, 592–596.

A review of the possibilities of a newly-invented apparatus for the accurate registering of pitch—the tonoscope.

54. *Mentality Tests: A Symposium.* J. Educ. Psychol., 1916, VII, 276–287.

A continuation of the symposium of leaders in the field of mental testing. A discussion of problems, developments, and future possibilities of the testing program.

55. *Using the Eye Instead of the Ear in the Training of a Musician.* Sci. Amer., May 13, 1916, 114, 506.

A description of the tonoscope and an explanation of how the instrument may be utilized by the singer, the player of instruments, the scientist, the public speaker, and the deaf.

56. *Blind and Their Sense of Capacity.* Outlook, 1916, CXIII, 147–148.

An article distinguishing between native sensory capacity and acquired ability. Report of tests made by the author and Mr. Ling on blind and seeing persons, the results of which show no significant differences in tactual, muscular, and auditory senses.

57. *The Frequency of Dreams.* Sci. Mon., 1916, II, 467–474.

An article giving both theoretical and experimental evidence on the hypothesis that " all persons dream all the time when they are asleep and sometimes when they are awake." The evidence is: (1) sense organs are subject to stimulation, (2) no part of the nervous system is ever wholly at rest, (3) internal stimuli, constantly active, play directly on the nerves and arouse nerve impulses which have mental correlates—dreams.

58. *Mentality Tests: A Symposium.* J. Educ. Psychol., 1916, VII, 348–361.

A continuation from the May issue.

59. *Vocational Guidance in Music.* Univ. of Iowa Monog., 1916 (First Series No. 2), 1–11.

Vocational guidance in music based upon laboratory measurements is shown to be working in a practical manner.

60. *How Psychology Can Help the Musician.* The Etude, 1917, XXXV, 89–90.

Outlining an inventory of musical talents and showing how these talents are interrelated in the individual.

61. *Auditory Memory.* The Music Superv. Jour., 1917, IV, 6–11.

An auditory memory test to be used primarily in the fifth grade. The purpose of the test is to determine native capacity for a particular content. A percentile rank table and various diagrams are given in the article.

62. *Apparatus.* Psychol. Bull., 1917, XIV, 15–16.

Comments on apparatus made by Gorten, Patten, Strein, Tilney, and Wethlo. The pieces described were " Ein Schallschreiber ", a projecting device suitable for exploring photosensitive areas, various means of securing a graphic record of the voice, clinical instruments for estimating muscle strength, and a new turbo-stroboscope.

63. *Avocational Guidance in Music.* J. Appl. Psychol., 1917, I, 342–349.

The need of avocational guidance is stressed since only a small proportion of those who pursue the art of music are going to pursue it as a profession. Therefore the guidance is more important than for the profession. The guidance is made possible through the use of tests in the elementary grades and in high school by using tests in the conservatories of music, and from consultation work.

64. *Measurement of Basic Capacities in Motor Ability.* Proc. Iowa Acad. Sci., 1918, XXV, 67–69.

Discussion of a series of motor tests which are basic in the diagnosis of fitness for various occupations requiring motor control. The tests described are as follows: (1) motor ability, (2) timed action, (3) simple reaction, (4) complex reaction, (5) serial action, (6) precision of action, and (7) strength and endurance.

65. *The Inheritance of Musical Traits.* Musician, 1918, XXIII, 605.

An approach to the study of the inheritance of musical traits showing the necessity of analyzing talent into factors for the purpose of experiment and measurement. A list of such factors is given.

66. *An Analysis of the Traits of the Musical Mind.* Proc. Music Teachers' Nat. Assoc., 1918, XL, 25–33.

An outline to be used in making an inventory of the musical mind. Includes musical sensitivity to impression and appreciation, musical action (voice or instrument or both), musical memory and imagination, musical intellect, and musical feeling.

67. *The Elemental Character of Sensory Discrimination.* Univ. of Iowa Stud. in Psychol., 1918, VII, 159–163; Psychol. Monog., 1918, XXV (No. 108), 159–163. (With Kwei Tan.)

The experiment showed that there was apparently no increase in discrimination of intensity of sound due to practice.

68. *The Sense of Rhythm as a Musical Talent.* Musical Quar., 1918, IV, 507–515.

Distinguishes between subjective and objective rhythm. Explains the nature of subjective rhythm by showing what it does: favors perception by grouping, adjusts strain of attention, gives feeling of balance, gives feeling of freedom, luxury, and expanse, gives us a feeling of power, stimulates and lulls, has preservative value as an instinct, finds resonance in whole organism, arouses and facilitates association, relieves us of monotony, and results in play. Shows the importance of rhythm for the musician.

69. *Correlation of Factors in Musical Talent and Training.* Univ. of Iowa Stud. in Psychol., 1918, VII, 49–92; Psychol. Monog., 1918, XXV (No. 108), 47–92 (With G. F. Mount.)

The factors investigated were: Pitch discrimination, consonance, intensity discrimination, hearing ability, time-sense, motor ability, free rhythm, regulated rhythm, rhythmic judgment, sing-

ing the keynote, singing the interval, singing the scale, voluntary control of pitch singing, auditory imagery, motor imagery, and tonal memory. These various factors were intercorrelated and the P.E.'s of each given. The correlations ranged from .94 ± .00 between instrumental training and musical training to —.04 ± .05 between musical enjoyment and vocal training. Detailed comments on the significance of the various correlations are given.

70. *The Comparative Sensitiveness of Blind and Seeing Persons.* Univ. of Iowa Stud. in Psychol., 1918, VII, 148–159; Psychol. Monog., 1918, XXV (No. 108), 148–159. (With T. L. Sing.)

An investigation to determine whether the blind have greater inborn sensory capacity than seeing persons. "The blind and the seeing . . . are, on the whole, equally sensitive to the direction of sound, intensity of sound, lifted weight, passive pressure, active pressure, and tactual space."

71. *Apparatus.* Psychol. Bull., 1919, XVI, 14–16.

A note on the types of tonoscopes described by various writers.

72. *Rôle of a Consulting Supervisor of Music.* Natl. Soc. for the Study of Educ., Yearbook, 1919, XVIII, pt. 2, 111–123.

Work suggested: (1) survey tests in the fifth grades, (2) follow-up work, (3) individual testing and counsel, and (4) organization of instruction in the schools.

73. *The Iowa Pitch Range Audiometer.* The Journal-Lancet, 1919, October 15, p. 1–8.

Describes the pitch range audiometer, which measures quickly and accurately the sensitiveness of the ear to a pure tone at any and every pitch within the range of hearing. The history of such a type of measurement is given.

74. *The Psychology of Musical Talent.* Silver, Burdett Company, 1919, pp. xvi+288 (Bevorly Ed. Series; ed. by W. W. Charters).

Its content appeals to those interested in music: its method and

treatment appeals to the educational psychologist. It is a scientific study of the artistic mind.

75. *Manual of Instructions and Interpretations for Measures of Musical Talent.* Columbia Graphophone Co., N. Y., 1919, pp. 16.

To be used with the author's musical tests. The instructions are given primarily with reference to the school room.

76. *An Open Letter to College Seniors.* Bull. Univ. of Iowa, 1920 (New Series No. 200).

Answers to a number of questions which should be taken up by a college senior before entering a Graduate College.

77. *The Inheritance of Musical Talent.* Musical Quar., 1920, VI, 586–598.

The complex elements involved in determining the inheritance of musical talent and suggestions as to a procedure in their measurement.

78. *A Survey of Musical Talent in the Public Schools.* Univ. of Iowa, Stud. in Child Welf., 1920, I (No. 2), 1–36.

A study of psychological individual differences in musical traits for the fifth and eighth grades in the public schools of Des Moines, Iowa. From the data thus secured, percentile rank tables, and norms were determined.

79. *Apparatus.* Psychol. Bull., 1920, XVII, 17–18.

A review of apparatus described by Bertram, Burtt, Dean and Bunch, Dunlap, Goldstein, Klopsteg, Nutting, and Seashore.

80. *George Trumbull Ladd.* Science, 1921, LIV, 242.

Recognizes Ladd as a great organizer and interpreter of new and relevant facts during the period (80's and 90's) when physiological, experimental, genetic, and abnormal psychology were gaining recognition in college curriculums in the United States.

81. *Psychology as a Career.* Science, 1922, LV, 381–384.

A presentation of the nature of psychology, the fields of

psychology both pure and applied, natural qualifications for a scientific career, training necessary, and types of careers.

82. *Wave Phase in the Localization of Sound.* Psychol. Monog., 1922, XXXI (No. 140), 1–6.

An "Introduction to following articles on wave phase: open air conduction; statement of observed facts, dated 1918; outline of laboratory problems, dated 1917."

83. *Sectioning Classes on the Basis of Ability.* School and Soc., 1922, XV, 353–358.

Presentation of the need, method, advantages, and objections to the plan of sectioning classes on the basis of ability.

84. *The Gifted Student and Research.* Science, 1922, LVI, 641–648.

A plea for the emancipation of gifted students, their early selection in college, and a presentation of procedure which will insure their maximum development.

85. *Comments on the Plan of Sectioning Classes on the Basis of Ability.* School and Soc., 1922, XVI, 514–517.

A collection of comments from several colleges and universities on the plan for sectioning classes. There were no adverse comments on the plan.

86. *Progressive Adjustment Versus Entrance Elimination in a State University.* School and Soc., 1923, XVII, 29–35.

A plan for the progressive adjustment of both superior and inferior students through the four levels of our educational system, viz., high school, junior college, senior college, and graduate college.

87. *The Iowa Pitch Range Audiometer and Its Uses.* The Laryngoscope, April, 1923.

The need of a pitch range audiometer, and characteristics of a good instrument; the development of the Iowa Pitch Range Audiometer.

88. *Individual and Racial Inheritance in Musical Traits.* Eugenics, Genetics, and the Family, 1923, I.

Presentation of the thesis that musical talent is resolvable into a number of inborn capacities, which may be isolated and measured adequately for statistical or experimental purposes.

89. *Measurements on the Expression of Emotion in Music.* Proc. Nat. Acad. Sci., 1923, IX, 323–325. (Read before the Academy, November 15, 1922.)

Discusses the technique used in the measurement of the composition of the tone which produces the expression of emotion.

90. *Sectioning on the Basis of Ability.* Bull. Amer. Assoc. of Univ. Professors, 1923, IX, 9–24.

Presenting the method, individual differences, the significance of individual differences to educational theory and practice, the basis of sectioning, organization of courses, and some general considerations relative to the loyalty of students and faculty are treated with clarity.

91. *Introduction to Psychology.* Macmillan Co., New York, 1923, xviii+422 pp.

"Not psychology, but to psychologize" is, according to the author, the educational aim of the book.

92. *Psychology and Service.* Bull. Univ. of Iowa, March 15, 1924 (New Series No. 275).

A discussion of the psychological equipment in the laboratory of the State University of Iowa and of the relation of psychology to the other departments and schools of the University.

93. *A Medico-Psychological Survey of Morons in Iowa.* The J. Iowa State Med. Soc., March, 1924.

Presenting to the Iowa State Medical Society a method of dealing with the moron—how to discover them and handle them.

94. *Recognition of the Individual.* Bull. of Eng. Educ., 1924, XV.

The principles to be considered in dealing educationally with individuals in school life.

95. *College Placement Examinations.* School & Soc., 1924, XX, 575–577.

The difference between college placement examinations and intelligence tests, the nature of the placement examinations, and the educational value of the placement examination.

96. *The Individual in Higher Education.* Pub. by National Research Council, 1926.

The central theme of this book is the progressive process of selection and elimination from the secondary school on up through the post-doctorate period. The author also presents a broad and penetrating view of the function of the modern college and university.

97. *Sectioning on the Basis of Ability.* Bull. Amer. Assoc. of Univ. Professors, 1926.

A report of the Committee on Intellectual Status of Students in the Association of University Professors. The article gives a clear picture of the present status of the practice of sectioning on the basis of ability.

Pamphlets and Leaflets

1. *The Measuring of Musical Capacities in the Public Schools.*

A general picture of what is involved in the scientific approach to an understanding of the musical mind.

2. *Symposium: Some Results of Current Research in the Psychological Laboratory of the State University of Iowa.*

The two main fields of research, viz., the Psychology of Music and the Basis Motor Capacities in which research is being done at the Psychology Laboratory of the State University of Iowa, are

presented, followed by a summary of twelve studies by various students.

3. *Recent Progress in Psychology of Musical Talent.* (Read at the Music Teachers' National Association, Chicago, December 30, 1920.)

The analysis and measurement of musical talent as developed in the Iowa University Laboratory.

4. *Hypnotism*—a syllabus of a lecture.

5. *Mediumship*—a syllabus of a lecture.

6. *The Graduate College.*

The following questions are discussed: Have I the ability? What are the marks of a good graduate student? Will it pay? Do I need it? Can I afford it? Is it the practical thing to do? Why not postpone it? What are the possibilities of stipends?

7. *An Open Letter to College Freshmen.*

Reminding the student that he is a bodily, an intellectual, a social, a moral, an aesthetic, and a religious being. Education should make the most of these natures in a well developed and balanced personality. He should choose for his training an institution with high standards in all. Helpful suggestions are given on self-inventory, choosing a job, how hard one should work, how far he should go, and the value of an education.

8. *Hearing: A Study in Experimental Psychology.*

An outline of experimental work in hearing the direction of sound, hearing ability, hearing tones, and hearing and singing. Pictures of research apparatus are shown.

9. *Outline of Elementary Psychology.* Course 1(2).

An outline of the class work in a three-hour course throughout the year, as used in the State University of Iowa about 1910. The students master four text-books, according to the plan, and all recitations are written.

10. *Mental Health.*

Mental health embracing the scope of mental life. The meaning of mental to physical health, and some general rules of mental health.

11. *Biological Classification of Feelings.*

The outline, from a biological viewpoint, is given under six heads. Those which affect (1) the conservation of the organism, (2) the perpetuation of the race, (3) the common welfare, (4) approbation and reprobation, (5) the welfare of others, and (6) relations between interactions.

12. *Dreams*—a syllabus of a lecture.

A consideration of the nature of sleep, origin and causes of dreams, explanation of typical dreams, general characteristics of dream consciousness, fulfillment of dreams, and significance of dreams.

13. *Voluntary Control of the "Eigenlicht."*

A leaflet containing four elementary experiments for the study of the voluntary control of the "Eigenlicht." By persistent and attentive effort one is to arrange the mass of the "Eigenlicht" in different shapes and record (1) time for producing the shape, (2) modifications of the shape, (3) color, and (4) the effect of the fatigue.

TEN VOLUMES OF IOWA STUDIES IN PSYCHOLOGY

REVIEWED BY

MABEL CLARE WILLIAMS KEMMERER

This review was prepared at the specific request of the editors, Dr. Starch and Dr. Miles. I was selected to write it for the reason of having had personal knowledge of and participation in practically every research that is contained in these ten volumes of Studies. Vol. I was issued prior to my actual connection with the Laboratory, but I claim an interest even in it, as I was one of the observers in Dr. Gilbert's study with which this volume begins. Although Vols. IX and X were published after my residence connection with the Department was severed, the actual work there reported was practically all done before my leaving.

Dr. Seashore has given unity and direction to the work of the Department with ever changing research personnel. He has conceived problems, methods and applications with a facility both discouraging and encouraging to his students. He has been the counselor and guide and sympathetic friend and has secured funds which grew increasingly more adequate to the needs of the investigations. He encouraged initiative and cautioned the overzealous and impractical attitudes. He has demonstrated comprehending insight, and always has typified true scientific method. During the earlier years he did much of the actual laboratory experimentation. The amount of this gradually decreased, however, so that more recently his participation has been wholly that of consultant, director and provider.

Nor have his students lacked originality and independence in investigation. It is they who have done the drudgery work incident to scientific progress. They, too, have submitted their plans and ideas and shared them freely. There has been true and successful coöperation and the results have usually been happy. These volumes do not cover all investigations made in the Laboratory.

Two methods are open to the reviewer: (1) to take each volume as a unit and summarize the contents; or, (2) to bring together articles on a given topic from all the volumes and thus throw more vividly into relief the progressive attacks upon a problem. The latter method seems the more logical and will be followed. Tables I and II are introductory and self-explanatory.

TABLE I. *General data concerning the first ten volumes of Iowa Studies in Psychology*

Vol.	Pp.	Year	Editor	No. titles	Dissertations	Psychol. Monog. Whole No.
I	92	1897	Patrick	5	..	..
II	163	1899	Patrick	4	..	..
III	144	1902	Patrick	5	1	..
IV	118	1905	Seashore	3	1	28
V	148	1908	Seashore	3	1	38
VI	177	1914	Seashore	10	7	69
VII	163	1918	Seashore	7	5	108
VIII	382	1922	Seashore	17	12	140
IX	262	1926	Seashore	7	6	167
X	112	1926	Seashore	6	5	168
Totals	1,761			67	38*	

* This figure is from memory and unverified.

TABLE II. *The number of articles on different topics*

I. Apparatus. (7)
II. Child Study. (2)
III. Sleep. (1)
IV. Taste. (1)
V. Dextrality. (1)
VI. Secondary Personality. (1)
VII. Illusions of Weight. (1)
VIII. Visual Illusions. (4)
IX. Blindness, Color Blindness, Physiology of Vision. (6)
X. Transfer of Training. (2)
XI. Mental Work. (1)
XII. Simple and Comp. Reaction. (2)
XIII. Motor Performance. (7)
XIV. Speech and Singing. (11)
XV. Pitch Discrimination. (9)
XVI. Consonance. (2)
XVII. Hearing Ability. (2)
XVIII. Imagery. (2)
XIX. Musical Talent. (3)
XX. Localization of Sound. (7)

I. APPARATUS

1. PATRICK, GEORGE T. W. *The New Psychological Laboratory of the University of Iowa.* 1902, III, 140–144.—The Department of Philosophy and Psychology moved in September, 1901, from an old and crowded brick building to the new Hall of Liberal Arts, a beautiful building of Bedford limestone. Forty-five thousand clear feet of floor space were allotted to it, with

freedom in planning the layout of rooms. The space was divided into two offices, two classrooms and seven laboratory rooms, all conveniently adjacent and connected through a switchboard. A sound, light and jar proof observing room was especially designed. This unique room has proved to be most satisfactory. The original group of rooms has been somewhat altered with passing of years, although the center of departmental activity remains as in the beginning.

2. SEASHORE, C. E. *A Spark Chronoscope with Accessories.* 1899, II, 153–158.—This very useful instrument has amply justified itself. The principle is that of a falling pendulum with a pointer which travels in front of a smoked paper surface. The pointer and a metal plate immediately behind the paper connect with the secondary terminals of an induction coil. A spark passes through the paper when the primary circuit of the induction coil is broken. The location of the spark dot is immediately read off from a scale calibrated in .01 second. The release of the pendulum either makes or breaks a stimulus circuit as desired. The pendulum can be adjusted for slow speed by weighting the upper bob, and substituting a corresponding scale. Accessory apparatus consisted of devices for producing sound and light stimuli, and an exposure shutter or tachystoscope.

3. SEASHORE, C. E. *An Audiometer.* 1899, II, 158–163. This is the well known Seashore Audiometer. The principle employed is that of varying the strength of an induced current with the number of turns of wire in the secondary coils. A receiver is introduced into the secondary circuit. In this circuit the coils are wound in forty sections, arranged in a series. A riding contact throws any number of these sections into circuit, thus varying the intensity of the sound. A dry cell, a galvanometer for securing a standard e.m.f. with necessary resistance coils, and a make-break key, form integral parts of the audiometer.

4. SEASHORE, C. E. *A Voice Tonoscope.* 1902, III, 18–28.

5. SEASHORE, C. E. *The Tonoscope.* 1905, VI, 1–12.—This instrument is constructed on the principle of the stroboscope. It translates sound vibrations into visual configurations, hence its

name. The model of the tonoscope described in the earlier article consisted of little else than a stroboscopic drum screen, a manometric capsule and a vacuum tube in circuit with an electro-magnetic fork. The speed of the drum was not controlled and two simultaneous readings were necessary, one of the vibration frequency of the tone sung, the other the speed of the drum. Later models employed a synchronous motor or a phonograph motor, and a metal siren screen was substituted for the paper one. The essentials of the instrument have remained unchanged, however, and it has proved to be a most useful instrument in research. Typical research problems are outlined in both articles.

6. ZUEHL, BENJAMIN FRANKLIN. *A Stroboscopic Device for Measuring Revolution Rates.* 1922, VIII, 98–101.—If the rate of one rotating disc is known, the rate of a second can be determined by finding the ratio between the two speeds stroboscopically. The rotating device for the standard is a phonograph motor. A scale for making frequency readings is given in terms of the number of revolutions per second of the second disc for each revolution of the standard disc. The advantages of the device are that it is accurate, adaptable to a wide range of frequency rates, is inexpensive and convenient for small laboratories.

7. SEASHORE, C. E. *A Method of Measuring Mental Work: The Psychergograph.* 1902, III, 1–17.—This instrument is in two parts, a stimulator and a recorder. The former consisted of a release mechanism for moving a cardboard disc carrying 100 individual signals around its periphery. Each signal became visible in turn through a small opening when the release mechanism was operated by means of four finger keys, pressed selectively by the observer in response to the signal. The recording device drew a strip of ticker tape under five pens, one for a time line, the other four corresponding to the four release keys. The resulting graphic record gave speed and accuracy measurements. The instrument is noisy and jerky in operation and needs constant adjustment. Accordingly, after serving in one or two studies, its use has been restricted for the most part to training exercises in the laboratory course.

II. Child Study

8. Gilbert, J. Allen. *Researches upon School Children and College Students.* 1897, I, 1–39.—This is a continuation of work begun by the author at Yale. Eleven tests of sensory and motor capacities were given to subjects between the ages of six and nineteen, inclusive. Full tables with accompanying graphs are presented. It is a fine piece of pioneer work.

9. Patrick, G. T. W. *Fatigue in School Children: A Review of the Experiments of Friedrich and Ebbinghaus.* 1897, I, 77–86.—Two noteworthy German researches are here made available to the English reader.

III. Sleep

10. Patrick, G. T. W., and Gilbert, J. Allen. *On the Effects of Loss of Sleep.* 1897, I, 40–71.—Three healthy young men were kept continually awake for about ninety hours and were subjected to physiological and psychological tests at intervals of six hours. Each set of tests consumed about two hours. Mental and physical changes incident to the progressive sleep fast, and to recovery from it, are reported in detail.

IV. Taste

11. Patrick, G. T. W. *On the Analysis of Perceptions of Taste.* 1899, II, 85–127.—The immediate occasion for these highly interesting and valuable experiments was the availability of an anosmic observer. The general occasion was the almost complete confusion of knowledge about taste perceptions. A great variety of taste stimuli were employed and several control observers were used. The results of all the experiments are fully presented and discussed.

V. Dextrality

12. Patrick, G. T. W. *Right and Left Handedness: A Review of Recent Writings.* 1897, I, 87–92.—Two German and three English articles are reviewed, compared and evaluated.

VI. Secondary Personality

13. Patrick, G. T. W. *Some Peculiarities of the Secondary Personality.* 1899, II, 128–152.—A very interesting case study

of automatic writing, with records, comments and critical analysis, is given. The tests were made both with and without hypnosis. The absurdity of the "spirit hypothesis" is emphasized.

VII. Illusions of Weight

14. Seashore, C. E. *The Material-Weight Illusion.* 1899, II, 1–35.—The apparent weight of an object is conditioned by the material of which it is made. Experiments were devised to secure quantitative measures of the strength of the illusion. The report closes with a discussion of economizing energy by the illusion.

VIII. Visual Illusions

15. Seashore, C. E. *Visual Perception of Interrupted Linear Distances.* 1899, II, 1–35.—Here was begun a practice that has continued to the present; that of affording opportunity to the students in elementary psychology to serve as observers in the laboratory. In this study, numerous variants of some of the common illusions, such as the Muller-Lyer, were employed and the results with interpretations are presented in full. This was the beginning of work upon visual illusions in the Iowa Laboratory. The standard dimension of 114 millimeters used in subsequent experiments was here introduced: it is three times the diameter of a silver dollar.

16. Seashore, C. E., and Williams, Mabel Clare. *An Illusion of Length.* 1902, III, 29–37.—A new illusion was teased out of the tangle of illusions in such forms as squares, L-shaped figures, and line and dot distances. This research paved the way for the one that follows.

17. Williams, Mabel Clare. *Normal Illusions in Representative Geometrical Forms.* 1902, III, 38–139.—This is the first dissertation (Ph.D.) published from the Department, and the second from the University. A three-year progressive study was made of the motives to illusion in a cylinder, exemplified by the silk hat, and related forms. Further data were secured upon illusions already known and three new ones were discovered and named the area illusion, the volume illusion and the illusion of

cylinder length. Full records are given for each series of measurements and the results are made readily available by their presentation in a summary table.

18. SEASHORE, C. E., CARTER, EDWARD A., FARNUM, EVA CRANE, and SIES, RAYMOND W. *The Effect of Practice upon Normal Illusions.* 1908, V, 103–148.—The illusion of cylinder length, the T-illusion, the Muller-Lyer illusion and the illusion of distance between circles were used as test cases for the determination of the effect of practice upon the strength of the illusion, both with and without knowledge of the illusion on the part of the observer. The illusions tend to persist with undiminished force under repeated practice periods so long as the observer has no knowledge of the illusion.

IX. BLINDNESS, COLOR BLINDNESS AND PHYSIOLOGY OF VISION

19. MINER, JAMES BURT. *A Case of Vision Acquired in Adult Life.* 1905, IV, 103–118.—A young woman with complete double congenital cataract was operated upon at the ages of twenty-two and twenty-three and was thereby awarded serviceable vision under proper correction. About a year after the final operation she became available for psychological study and she proved to be very keen in introspection. Sensitivity and discrimination tests were made for several senses, and the learning ability was studied. An outstanding observation related to her very superior color discrimination. Single, binocular vision occurred at times. Visual experiences had decidedly less meaning than those of a normal person.

20. SEASHORE, C. E., and LING, T. L. *The Comparative Sensitiveness of Blind and Seeing Persons.* 1918, VII, 148–158.—This study is a determined attack upon the problem of compensating delicacy in the senses of touch and hearing in blind persons. The common belief that such exists seems not to be based upon fact. Children in high school grades in the Iowa School for the Blind were studied, and as controls, seeing children of corresponding grades. The results reveal no significant constant tendency in favor either of the blind or the seeing. Both, under the conditions imposed, are equally sensitive to direction of sound,

intensity of sound, lifted weight, passive pressure, active pressure and tactual space.

21. SEASHORE, C. E., and TAN, KWEI. *The Elemental Character of Sensory Discrimination.* 1918, VII, 159–163.—This is really a continuation of the article just above, and so is included under this general head although sound stimuli were used. The purpose of the article is to present further data to the effect that discriminative ability does not improve with practice.

22. WILLIAMS, MABEL CLARE. *An Unusual Case of Partial Color Blindness.* 1918, VII, 1–30.—The young man experimented upon confused the colors red and yellow, and blue and green. He saw two spectral hues, "red" and "green." Preliminary tests were made at the Iowa laboratory; then through a grant from the Graduate College, he was taken to the Nela Research Laboratory at Cleveland, permission to work there having been graciously accorded. Extensive sensitivity and discrimination measurements were made by various methods. The results are unusually consistent. The current theories of color vision did not permit an exact diagnosis of the type. The father and one brother were reported as having the same defect; two other brothers had normal color vision.

23. TRAVIS, ROLAND C. *A Phenomenon in Vision Similar to the Refractory Phase.* 1926, X, 1–17.—A threshold light stimulus under dark adaptation is not sensed if it follows too closely upon a former one. A definite refractory period intervenes. Degree of adaptation, intensity and time spacing of stimuli, were independently varied under carefully controlled conditions. This refractory period as well as the threshold is a function of the intensity of the stimulus and the state of light and dark adaptation of the eye.

24. TRAVIS, ROLAND C. *The Diagnosis of Character Types by Visual and Auditory Thresholds.* 1926, X, 18–37.—Schizophrenic and psychoneurotic groups were subjected to certain tests along with controls, in the search for a reliable means of more adequately separating the groups. The visual apparatus employed in the previous study was used. The method of threshold

discrimination differentiated reliably the schizophrenic and psychoneurotic groups.

X. Transfer of Training

25. Gilbert, J. Allen, and Fracker, G. Cutler. *The Effects of Practice in Reaction and Discrimination for Sound upon the Time of Reaction and Discrimination for Other Forms of Stimuli.* 1897, I, 62–71.—A very noticeable reduction in time of reaction was noted, whether to practiced or unpracticed stimuli, but this practice alone did not reduce the time of discrimination and choice. Practice effects in discrimination of sounds were transferred to discrimination for other stimuli.

26. Fracker, George Cutler. *On the Transference of Training in Memory.* 1908, V, 56–102.—Poetry, shades of gray, tones, geometrical figures and numbers were employed as initial and terminal stimuli. The practice problem was to remember the order of four tones given in a group, an unreported group being carried in mind by the observer; that is, he always reported the grouping before the last. Copious introspective notes were secured. The most essential element in improvement and transference was found to be individual imagery.

XI. Mental Work

27. Seashore, C. E., and Kent, Grace Helen. *Periodicity and Progressive Change in Continuous Mental Work.* 1905, IV, 46–101.—This study in the efficiency of continuous mental work deals with sensitivity, discrimination and memory. Fatigue was the primary object of interest and search. The results are summed up with reference to the methods employed, certain characteristics of efficiency, especially periodic change and progressive change. The conclusions are itemized.

XII. Simple and Compound Reaction

28. Seashore, C. E. *Motor Ability, Reaction Time, Rhythm and Time-Sense.* 1899, II, 64–84. This is an early " statistical " study on the time of mental processes. It was made before the deification of statistics. Apparatus and procedures are carefully

described and the records are presented in detail. The results are more confirmatory than novel.

29. HANSEN, C. FREDERICK. *Serial Action as a Basic Motor Capacity.* 1922, VIII, 320–382.—The purposes set forth in the study are: to secure a simple and practical device for measuring speed and accuracy in serial action; to standardize thoroughly the variables in the procedure; and to measure the performance of representative groups of persons. The apparatus is an ordinary typewriter with a commutator attached to the carriage in such a way as to throw into circuit any one of four spatially separated telephone receivers. The machine wrote the record of order of keys against which errors could be checked. The aggregate time for a whole "line" was taken. Visual stimuli, letters, were also used, the characters being exposed one at a time, serially. Among the conclusions we find that a "personal equation" of speed appeared. Mean speed and mean accuracy were not consistently related. A disturbingly large number of variables appeared.

XIII. MOTOR PERFORMANCE

30. REAM, MERRIL J. *The Tapping Test: A Measure of Motility.* 1922, VIII, 293–319.—The general problem was to measure a basic motor capacity. The telegraph key was adopted as the tapping instrument, after careful consideration and testing of other devices. After much experimentation the amplitude of movement of the key button was set at 1 mm. As a recording device a Veeder counter was connected with a metronome, battery, tapping key and contact keys in such a way that a period of five seconds was sharply defined and the number of taps made in that time read from the counter. Variables were carefully determined and controlled and a standard procedure set forth. Some suggestive records are presented, but the main purpose of the study was the standardization of the apparatus and method.

31. WICKHAM, DOROTHEA EMELINE. *Voluntary Control of the Intensity of Sound.* 1922, VIII, 260–267.—The aim of this investigation was to establish a standard test for voluntary control of intensity of sound in music. A modification of a Seashore audiometer which produced stronger sounds than usual was used.

A tone from a 100 v.d. fork was presented as a standard stimulus; the observer tried to reproduce its intensity by starting with a weak tone and increasing to the standard intensity. A quick glide was made for ten standard intensities. Distribution curves for unselected observers and for students of music are given.

32. KOERTH, WILHELMINE. *A Pursuit Apparatus: Eye-Hand Coördination.* 1922, VIII, 288–292.—A modification of the pursuit apparatus introduced by Miles. A small brass target is sunk in a wooden disc rotated by a phonograph motor. A commutator is set in the edge of the wooden disc. A battery Veeder counter and flexible finder or pointer are in circuit with the target and commutator. When the finder is held on the rotating target the counter is operated through the commutator. The problem is to keep the finder on the target. Norms and practice records are given. The apparatus has proved to be interesting, useful and suggestively diagnostic of types.

33. ROSS, FELIX BRUENE. *The Measurement of Time Sense as an Element in the Sense of Rhythm.* 1914, VI, 166–172.—A make and break contrivance was attached to the flywheel of a synchronous motor and marked off accurately any sound interval desired by clicks in a telephone receiver. One short interval was thrown into the last five or ten intervals. The problem for the observer was to identify this short interval. The main purpose of the study was to establish a procedure. This test is an ancestor to the time sense measure of musical talent as finally adopted in Seashore's measures.

34. SEASHORE, ROBERT HOLMES. *Studies in Motor Rhythm.* 1926, IX, 142–189.—As stated in the report, the aim of this research was to develop a measure of precision in rhythmic action and to analyze this function in relation to other motor and cognitive factors. The ultimate purpose was to provide a standard measure of rhythmic auditory-motor coördination. The ever available phonograph motor was employed both to give the rhythmic groups of sounds which were the stimuli, and for recording graphically the observer's expressions of these rhythmic groups. Performance in this test was correlated with that in ten other

motor and sensory psychophysical tests. A general factor called "basic rhythm" appeared; also a general "kinesthetic memory." The test proved very reliable.

35. ROBINSON, BENJAMIN W. *An Experimental Study of Certain Tests as Measures of Natural Capacity and Aptitude for Typewriting.* 1926, X, 38–53.—A narrow, fundamental ability to make the coördinations necessary to the attainment of proficiency in the touch system of typing was measured by a battery of tests covering a rather diverse range of capacities. The most important single test used was typing from copy, for three minutes, about 1,000 strokes. Speed and errors were determined. A rather full statistical treatment of results is given. Correlations among the several tests were rather low.

36. OHMANN, OLIVER A. *The Measurement of Capacity for Skill in Stenography.* 1926, X, 54–70.—This is a logical continuation of the preceding study. The point of departure was a rather elaborate analysis of psychological abilities assumed to be required in stenographic work. Tests adopted were: motility, language, following directions, memory span, substitution, vocabulary, spelling, handwriting, intelligence and character. A standard dictation letter to be transcribed was composed, with procedure for administration. The results show that a criterion of considerable promise had been found, having prognostic value.

XIV. SPEECH AND SINGING

37. MILES, WALTER R. *Accuracy of the Voice in Simple Pitch Singing.* 1914, VI, 13–66.—Two phases of simple pitch singing were studied, the ability of the voice to reproduce the pitch of a tone, and the ability to make faint shadings in pitch, sharp or flat. The Seashore tonoscope constituted the essential apparatus. Preliminary investigations were made upon the influence of voice range, standard tone intensity, voice volume, standard tone timbre and voice timbre, on the accuracy of voice control. Very decisive results were secured. The test is one of motor control and as a musical test it bears the same relation to the motor side as pitch discrimination does to the sensory side.

38. KNOCK, CARL J. *Visual Training of the Pitch of the Voice.* 1922, VIII, 102–127.—The research had a three-fold object: to determine the effect of accurate checking of errors on accuracy in pitch singing; to determine the elements responsible for inaccuracy; and to isolate factors in improvement with practice. The Seashore tonoscope was again called into use. The results are presented in full, summarized, and the conclusions are specific rather than general.

39. BRENNAN, FLORA MERCER. *A Report of Three Singing Tests Given on the Tonoscope.* 1926, IX, 249–262.—Serves the very useful purpose of reviewing and unifying the conclusions in previous researches employing the tonoscope. In reading it one becomes impressed with the service in research rendered by this instrument.

40. MERRY, GLENN N. *Voice Inflection in Speech.* 1922, VIII, 205–229.—A pioneer piece of work in the transcription of speech as recorded on a phonograph disc or cylinder to (smoked) paper, revealing in great detail and accuracy the form, frequency and amplitude of the sound waves. A particularly ingenious timing method was devised. Sample tracings are figured in the report. A workable method of reading the graphs was invented. The article is copiously illustrated with typical records.

41. METFESSEL, MILTON. *Technique for Objective Studies of the Vocal Art.* 1926, IX, 1–40.—The great advantage of assigning a succession of workers to the same general problem, which has throughout been an established policy at the Iowa Laboratory, is shown by the comparison of the apparatus described here, and that by Dr. Merry above. The one is the lineal descendant of the other. Here is an attempt to develop an adequate setting in which the investigations of the vocal art may proceed. It involves the description and construction of a simple and accurate apparatus, and the recommendations for a technique of procedure. The photographic method of recording is substituted for the earlier pantographic method. While this advance resulted in greater economy of time and effort, it has now (1928) been quite outdistanced. The history of the investigations upon the

voice forms one of the most romantic chapters in the growth of the Iowa Laboratory.

42. SIMON, CLARENCE. *The Variability of Consecutive Wave Lengths in Vocal and Instrumental Sounds.* 1926, IX, 41–83.—Vibration frequency was read from the tracing upon a strip of motion picture film passing at a known rate in front of a beam of light. The light came from a sensitive (manometric capsule) flame. The source of constant motive power was the synchronous motor of the oft used tonoscope. This method was compared with a time line method and was found to have the same reliability. The ideal speed of the film was about 2,000 to 2,500 mm. per sec. In the second half of the research, the apparatus and method were put to use. It was found that there were no tones of constant pitch, in either vocal or instrumental sounds.

43. SCHOEN, MAX. *An Experimental Study of the Pitch Factor in Artistic Singing.* 1922, VIII, 230–259.—The Seashore tonoscope and the Merry pantograph transcribing apparatus were again used. "Ave Maria" as sung (phonograph record) by five world famous artists was selected for study, particularly because of the prevalence of long sustained tones. There are 106 sung tones and data were obtained for every tone for the following items: attack, release, predominant pitch, vowel, tonal movement, crescendo, successive predominant pitches, and deviations. The results are clearly summarized. A second part of the article deals with the vibrato, its nature, significance and its measurement in famous singers, and its probable physiology and psychology. The vibrato, a periodic pitch-intensity phenomenon, is due to a neuromuscular condition, and has its seat in the muscles controlling the larynx in phonation.

44. KWALWASSER, JACOB. *The Vibrato.* 1926, IX, 84–108.—Simon's photographic apparatus was employed. Part of Schoen's earlier work was substantiated, part modified. The vibrato is now regarded as a phenomenon of three variables: pitch, intensity and time. The author emphasizes the fact that the art of singing is not based upon a science of singing, and voice teachers stress only the pitch variable in the vibrato.

45. TRAVIS, LEE EDWARD. *A Phono-Photographic Study of the Stutterer's Voice and Speech.* 1926, IX, 109–141.—The photographic apparatus and method were all ready for use. The subjects were drawn from the speech clinic. Pictures of the stutterer's voice were made under conditions of ease and naturalness, under emotive threat, and under emotive stimulation. One striking result is the muscular fixation after emotional shock in the stutterer as compared with the nonstutterer. Emotion in the former decreases the flexibility of the voice, in the latter it increases it. Some very significant problems relative to the obscure nature of stuttering are precipitated by this study.

46. TRAVIS, LEE EDWARD, and DAVIS, MILDRED G. *The Relation Between Faulty Speech and Lack of Certain Musical Talents.* 1926, X, 71–81.—The Seashore tests of musical talent, pitch, intensity, and tonal memory were given to groups of students in speech courses, who were assigned by their instructors into three classes on the basis of ability to speak. The three Seashore tests uncovered a real difference between good speakers and those with faulty speech in regard to whatever the tests really measure.

47. ERICKSON, CARL I. *The Basic Factors in the Human Voice.* 1926, X, 82–112.—This is an historical and analytical study of the human voice, its nature, production and control. The analysis is chiefly psychological and is carried out in terms of the five basic factors of pitch, intensity, time, timbre and volume. This research very conveniently sums up the present knowledge about the voice and the keen analysis of the whole field lays solidly the foundation for further work.

XV. PITCH DISCRIMINATION

48. SEASHORE, C. E. *Hearing Ability and Discriminative Sensibility for Pitch.* 1899, II, 55–64.—Pitch discrimination has been an enduring subject of investigation at Iowa. In this article there is described for the first time the standard series of tuning forks, consisting of an A fork of 435 vibrations per second and ten others with increments of ½, 1, 2, 3, 5, 8, 12, 17, 23, 30 vibrations above 435. This was not the very first set of differential forks, for an earlier one of eight forks is still extant. At

this time (1899) no resonators were used, the forks being struck upon a rubber covered rod and held close to the ear. The purpose of this study was to find some relation between hearing ability and pitch discrimination. This was before correlation formulae had come into general use, so an attempt was made to picture the relation in tabular form. Here, also, in some experiments made by the reviewer, then an under-graduate, is presented the first evidence that pitch discrimination does not improve with practice after the real level (physiological threshold) has been reached.

49. SMITH, FRANKLIN ORION. *The Effect of Training in Pitch Discrimination.* 1914, VI, 67–103.—By this time the pitch discrimination apparatus and methods had become permanently standardized. A better set of forks was tuned to the original increments and Koenig resonators intensified the tones. Both school children and adults were tested, in groups and as individuals. The results in general show only slight or no improvement with practice. Those who did improve had very high initial thresholds. Under favorable conditions the physiological threshold may be reached in a single sitting for more than half of the cases. With others, special instruction is necessary to get below the cognitive threshold. No improvement with age was noted. In this article mention is first made that better results are obtained under mild distraction as in tracing a maze or crocheting. Correlation formulae were used to some extent.

50. VANCE, THOMAS FRANKLIN. *Variation in Pitch Discrimination Within the Tonal Range.* 1914, VI, 115–149.—After an historical résumé of previous work, the author describes his apparatus and procedure. Tests were made at six levels in the tonal register: 64, 128, 256, 512, 1,024 and 2,048 vibrations. Special forks were constructed for the two lowest levels, and special tuning weights used on all variable forks. Discriminative ability was found to be decidedly keener in the middle levels. No striking difference was found between the musical and nonmusical.

51. VANCE, THOMAS FRANKLIN. *The Lower Limit of Tonality.* 1914, VI, 104–114.—Two electro-magnetic forks (one a driver) were arranged in tandem. Pitch was varied by means of sets of weights, from 18 to 12 v.d. The stimulus or driven fork,

free from accessory noises, was set up in the sound proof observing room. Previous work of Imai was confirmed, that under very favorable conditions a tone of twelve vibrations can be sensed. A careful study of variables influencing the threshold was made.

52. ANDERSON, DAVID ALLEN. *The Duration of Tones, the Time Interval, the Direction of Sound, Darkness and Quiet, and the Order of Stimuli in Pitch Discrimination.* 1914, VI, 150–156.—The title is self-explanatory. A short duration of tone was found favorable. Short time intervals were best. It made little difference from which one of four cardinal points the sounds came and no constant effect of order of presentation appeared.

53. STEWART, ROLLAND M. *The Effect of Intensity and Order on the Apparent Pitch of Tones in the Middle Range.* 1914, VI, 157–160.—Variation in intensity between a pair of compared tones results in poorer pitch discrimination than when the intensity is constant. As regards order, Anderson's conclusions were sustained.

54. HANCOCK, CLARA. *The Effect of Intensity of Sound upon the Pitch of Low Tones.* 1914, VI, 161–165.—This is a reëxamination of some findings made in the study by Miles. A series of differential forks with 128 v.d. as the base was employed. No mechanical device was used to secure intensity differences. The faintest and loudest tones producible from a given pair of forks constituted the stimuli. The pitch illusion of judging the louder sound as lower was substantiated.

55. SYLVESTER, REUL H. *Some Standardizing Tests on Stern's Tone Variator.* 1914, VI, 173–177.—The purpose was to determine how reliable the tone variator was for pitch discrimination experiments. It was found not to be reliable for research requiring accuracy in pitch.

56. SEASHORE, C. E., and MOUNT, GEORGE H. *Correlation of Factors in Musical Talent and Training.* 1918, VII, 47–92.—Here is brought together the assembled wisdom derived from experimentation upon various aspects of musical talent during fifteen years. The mass of accumulated data was enormous, and a real service is rendered by this summary and critical evaluation.

Pearson's formula was used for the correlations, the presentation of which forms the bulk of the article. The most valuable part of the report is the final section on "some general considerations and conclusions."

XVI. Consonance

57. Malmberg, Constantine Frithiof. *The Perception of Consonance and Dissonance.* 1918, VII, 93–133.—Preliminary work, culminating after passing through the hands of others, in the consonance test of Seashore's musical talent measures. The object of the investigation was to establish the ranking order of the musical intervals within the octave C′C″, with respect to the degree of consonance. Various sources of tone were used. A definition was formulated; criteria were worked out. And finally norms, showing the order of consonance-dissonance for the piano, were secured, with tentative directions for a standard test.

58. Gaw, Esther Allen. *A Revision of the Consonance Test.* 1918, VII, 134–147.—Dr. Gaw modified the consonance test as left by Malmberg, by eliminating certain undesirable intervals and the demerit system of scoring, and simplified the definition and concept of consonance. Norms for children were secured.

XVII. Hearing Ability*

59. Bunch, Cordia C. *The Measurement of the Acuity of Hearing Throughout the Tonal Range.* 1922, VIII, 45–82.—In this research is found one of the most beautiful examples of persistence under repeated failure in the designing of a piece of apparatus; with success beyond expectations after three years' work. It was thus that the Iowa pitch range audiometer came to be. As read in the report the story sounds simple. But if you

* That the Seashore audiometer described in Vol. II had not been the chief instrument of a major research was a surprise to the reviewer as it has been in almost constant use. While some results of measurements made with it are reported in Vol. II, its use seems to have been incidental. The explanation is, of course, that hearing ability is not usually regarded as of primary importance in the diagnosis of musical talent, which has been the dominant problem in the laboratory. So long as fair hearing ability was possessed, the hearing of musical tones was possible. I am not, obviously, referring to intensity discrimination, which is of great diagnostic value. Mention is made here and there of the search for tonal gaps in pitch hearing.

had been on the ground and had watched every step; if, like myself, you had been with Dr. Seashore and Dr. Bunch, on the night when the "last resort" was tried and found to *work,* you would have a tender feeling toward it, too. Read the description in the article, see "Bunch's grill," as we affectionately termed it, in *b* of Fig. A, and below it the final model, employing the same principle. See also the curves for types of ear defects and for normal persons. The audiometer and Dr. Bunch then went to the otological clinic in the medical college and further reports have been published from there.

60. ZUEHL, BENJAMIN FRANKLIN. *Measurement of Auditory Acuity with the Iowa Pitch Range Audiometer.* 1922, VIII, 83–97.—Norms were necessary and the author of this study has supplied them. Standard curves are established for children, young adults and older persons.

XVIII. IMAGERY

61. AGNEW, MARIE. *A Comparison of Auditory Images of Musicians, Psychologists and Children.* 1922, VIII, 268–278.

62. AGNEW, MARIE. *The Auditory Imagery of Great Composers.* 1922, VIII, 279–287.—These are posthumous articles, both on the same general topic. A set of five introspective questions about images, with a rating scale of 0–6, was sent to selected members of the Music Teachers' National Association. Seventy-six replies furnish the data for a distribution curve, the high point of which fell at number 6 of the scale, with 5 also very high, and the other points almost zero. A comparison curve of unselected adults and children was of very different contour. The psychologists were very wary and their curve was almost flat. The bulk of the report is composed of illuminating introspections. In the second article the writings of great musicians were searched for descriptive accounts of their imagery, which apparently was very prominent and useful.

XIX. MUSICAL TALENT (GENERAL)

63. GAW, ESTHER ALLEN. *A Survey of Musical Talent in a Music School.* 1922, VIII, 128–156.—Some twenty-seven tests

developed in the Iowa Laboratory were arranged in a battery and used on a number of students in the school of music at Northwestern. The purpose was to find out how music students would rank in the various forms of the tests, and to develop a procedure in talent analysis serviceable to music schools. A profile talent chart was made for each pupil. The article closes with some practical suggestions.

64. STANTON, HAZEL MARTHA. *The Inheritance of Specific Musical Capacities.* 1922, VIII, 157–204.—The Seashore measures of musical talent, with a supplementary questionnaire, were given to all available members of the families of several famous musicians, whose names are withheld. The study was made possible through the coöperation of Dr. C. B. Davenport. Pedigree talent charts for all persons measured are given, with full case histories. Types of mating are presented. The tests very successfully distinguished between musical and nonmusical members (of whom there were only five) of the several family groups.

65. BRENNAN, FLORA MERCER. *The Relation Between Musical Capacity and Performance.* 1926, IX, 190–248.—As stated, the purpose of this study was to establish a procedure for the investigation of relationships between musical capacity tests and musical performance, to draw tentative conclusions regarding such relationship, and to suggest further research. Twelve capacity tests were employed. Measurement of performance was subjective, being made by a court of judges part of whom were professional musicians or "experts." The identity of the performers was unknown to the judges. Criteria for judging were very carefully defined. The ratings of the expert judges were more valid than those of the nonprofessional (in music) judges. Certain capacity tests correlated highly with the rated performance.

XX. LOCALIZATION OF SOUND

66. SEASHORE, C. E. *Localization of Sound in the Median Plane.* 1899, II, 46–54.—Here begins another perpetual problem that has been variously attacked. Tentative feelers were put out for constant tendencies in sound localization, and those that were

firmly grasped have held steady. It is not necessary to enumerate them.

67. STARCH, DANIEL. *Perimetry of the Localization of Sound.* 1905, IV, 1–45.

68. STARCH, DANIEL. *Perimetry of the Localization of Sound.* 1908, V, 1–55.—These two articles are parts of the same study, a remarkable example of patience and persistence, with a thoroughness that decides forever. The very versatile Seashore sound perimeter made the research possible. The problem was to determine how and how well the direction of sounds was heard. The surface of a sphere centered at the head was surveyed every 15 degrees vertically and horizontally, with the 1 p.d. as the unit searched for. The second part deals with certain variables as monaural hearing, pitch and intensity influences, effect of timbre, and misplacements. Obviously, the apparatus had to be adapted to the several problems. In concluding remarks the bearing of the findings upon a theory of sound localization is discussed, with the final adoption of the " intensity-quality " theory.

69. STEWART, G. W. *Binaural Beats.* 1918, VII, 31–46. This article comes from the department of physics, which has coöperated with psychology in working out elusive sound laws. Very definite phenomena occur when two tones differing in frequency are lead one to each ear; as, for instance, beats, the minimum intensity of which does not approximate zero. When the tones are of the same intensity and phase, median localization occurs. Change in phase produces lateral displacement. A theory of binaural beats is given, together with anatomical considerations concerning the functioning organs.

70. STEWART, G. W. *The Intensity Logarithmic Law and the Difference of Phase-Effect in Binaural Audition.* 1922, VIII, 30–44.—The author's summary is quoted in full: " The ratio of the phase difference at the ears to the angular displacement of the fused sound from the median plane is approximately proportional to the frequency of the pure tone employed. This ratio is approximately the same for the three individuals upon whom extensive experiments have been made. There is an upper frequency limit of the phase-effect, averaging 1,260 for sixteen observers,

the range of the tests being 200 to 2,000 v.d. Tests with one observer up to 4,000 gave no indication of the recurrence of the phase-effect, at higher frequencies. The results upon the phase-effect, combined with earlier published results upon the effect of varying intensity-ratios at the ears show that the phase-effect cannot be explained in terms of intensity and that the organs of hearing must respond to phase as such, as phase and intensity are the only physical variations possible in a pure tone."

71. SEASHORE, C. E. *Wave Phase in Open Air Localization of Sound.* 1922, VIII, 1–6.—This short paper outlines the growth of experimentation upon the localization of fused sounds (wave phase effect) from the time the Laboratory became interested in it, and serves as an introduction to the following study. The big advance over all previous work noted here is the discarding of sound conduction devices and simply using open air conduction of the sound to the ears. This apparently simple change was the missing key to the solution of many apparently conflicting phenomena. Reference is made to the practical value of this work in submarine war service.

72. HALVERSON, HENRY M. *The Rôle of Intensity in Auditory Wave Phase.* 1922, VIII, 7–29.—The author's possession of an auditory organ matchless in its perfection rendered him peculiarly fit to undertake this delicate problem. His ear is literally a gift of the gods. For so complicated a study the apparatus used, merely an oscillator, two telephone receivers and a meter stick, was unbelievably simple. The specific points covered in the report are a statement of the fundamental facts concerning the phantom sound, comparison of tones of different pitch, effect of the direction of the current, variation in the absolute intensity of the sources, relation of distance to loudness, effect of moving one source, localization outside the line of the receivers, timbre, phantoms of fundamentals and overtones. (A continuation of this research was published in the *Amer. J. Psychol.,* April, 1922.)

A COMPARATIVE STUDY OF THE PERFORMANCES OF STUTTERERS AND NORMAL SPEAKERS IN MIRROR TRACING [1]

BY

LEE EDWARD TRAVIS

Studies[2] of the time of initiation of simultaneous antitropic movements of the hands (abduction and adduction) and of the instant of appearance of action-currents in the forearms during simultaneous voluntary flexion of the digits of the two hands have revealed striking differences between right-handed stutterers and right-handed normal speakers. These studies were undertaken to determine native handedness. A wide variety of general motor tests have been used to this end but it is felt that for all of them, at least in adults, the effect of years of training may largely obscure the original physiological preference. That it is important to discover the original physiological preference in stutterers seems evident from numerous accounts which have stated that stuttering has followed the enforced training of a naturally left-handed child to write with the right hand. If one could always obtain a history that a right-handed stutterer had been left-handed in childhood there would be no need of a test to determine native handedness. But the majority of case histories are negative in this respect. In carrying these studies further the present experiment was undertaken. It consisted in comparing right-handed stutterers with right-handed normal speakers in a mirror-tracing situation. More particularly it concerned a comparison of the two groups from the standpoint of superiority of the right or left hand.

Mirror-drawing as a psychological experiment has been used

[1] This study was carried on during the writer's tenure as a National Research Council Fellow in the Biological Sciences.

[2] To appear in forthcoming issues of the Archives of Neurology and Psychiatry.

since 1898 when *Henri* (1) reported studies on muscular sense and tactual space perception. Although it has been used primarily since this in learning experiments it seemed especially adaptable to our studies since it confronted the subject with a relatively new task in which the two hands were on an approximately equal basis. Of course long practice in all of our cases had made the right hand the more facile but the mechanics of merely tracing the star in which this difference in facility might be expected to enter are considered a very minor factor in the total mirror-drawing situation. The reversal in certain respects of the natural relationships is the most important aspect of this experiment and the one which in the light of some other studies now being carried on appeared capable of opening up some leads for us.

Method [3]

A six-pointed star was used for tracing. A subject was given the usual instructions to trace the outline of the star, starting in an indicated direction, as rapidly and as accurately as possible. No consideration, however, was given to corrective movements. Only the time element was taken into account in the present study. A certain number of subjects made a first trial with the left hand, followed by a series of five trials with the right hand and a second trial with the left. A greater number of subjects made only two tracings, the first with the left hand and the second with the right.

Tests were made to decide which eye was habitually used as the lead or dominant one and the results are presented in connection with those obtained in the mirror tracing experiment.

The *Parson's* (3) manoptoscope [4] was employed to determine

[3] The main principles of the mirror drawing apparatus are so well known and understood that it seems unnecessary to give a description of our set-up. For those who care to acquaint themselves with the common type of apparatus used in this connection see Whipple, Manual of Physical and Mental Tests, Complex Processes, page 120. For the history of mirror drawing as a laboratory method, see Carmichael (2).

[4] Manoptoscope is the trade name for an instrument manufactured by C. H. Stoelting Co., Chicago, which takes advantage of unilateral sighting in binocular vision.

eyedness. An individual is considered right- or left-eyed if he consistently signifies a preference for either one or the other in sighting and amphiocular if he manifests no fixed preference for either eye in sighting.

Data.

Right-handed adults [5] varying in age from seventeen to thirty-five years served as subjects in this study. An approximately equal number of women served in each group. In order to compare the performances of the two groups it was considered essential to keep them comparable in this respect because practically all previous studies have showed women to be superior to men in mirror tracing.

In Table I it is seen (a) that for the first trial with each hand the proportion of stutterers doing better with the left than with the right is significantly greater than the proportion of the normals doing better with the left than with the right, and (b) that a significantly larger proportion of the stutterers are left-eyed.

Table II shows that for the first trials with each hand a significantly larger proportion of the stutterers did better with the left than with the right hand while a significantly larger proportion of the normals did better with the right than with the left.

In Table III it is seen that the proportion of stutters doing better in the second trial with the left hand than in the fifth trial with the right is significantly greater than the proportion of normals reacting in this same way. Table IV presents the fact that a significantly larger proportion of stutterers did better in the second trial with the left hand than in the fifth trial with the right while a significantly larger number of normals did just the opposite.

When we compare the two groups in regard to mean times we do not find such definite differences. Table V shows that the normals are genuinely superior to the stutterers in tracing the star for the first time with the right hand. There does not

[5] An individual was considered right-handed if at the time of observation he wrote, threw, tied his tie, held a razor, combed his hair, etc., with the right hand.

appear to be such a genuine difference between the two groups in regard to the left hand. However, the normals are again better than the stutterers. Table VI indicates that the stutterers do significantly better in tracing the star for the first time with the left hand than for the first time with the right. There is not such clear indication that the normals do just the reverse.

As shown in Table VII there is no conclusive evidence that the normals do better in the fifth trial with the right hand than the stutterers although they show some superiority. There is no real difference between the groups in regard to the second trial with the left hand. In Table VIII the stutterers show no superiority in the second trial with the left hand over the fifth trial with the right, but there is a possibility that the normals did really better in the fifth trial of the right hand than in the second trial with the left.

TABLE I. *Comparison of groups for first trials of the two hands*

Group	Per cent doing better in 1st trial left hand	Per cent doing better in 1st trial right hand	Per cent right eyed	Per cent left eyed	Per cent amphi-ocular	Number of cases
Normals	22	78	73	22	5	55
Stutterers	86	14	50	45	5	48
Observed difference and its P.E.	64[6]±5.0[7]	64±5.0	23±6.2	23±6.2	0	

[6] An observed difference is considered significant if it is at least three times its probable error.

[7] The probable errors of the percentages were obtained by the formula $P.E._p = .6745\sqrt{\frac{pq}{n}}$ where p equals the percentage or proportion, q equals the difference between p and 1.00 and n equals the number of cases. The probable errors of the observed differences between proportions were then obtained by the formula

$$P.E._{diff.} = \sqrt{P.E._{p1}^2 + P.E._{p2}^2}$$

TABLE II. *Comparison of the two hands (first trials)*

Hand	Normals Per cent doing better	Stutterers Per cent doing better
Left (1st trial)	22	86
Right (1st trial)	78	14
Observed difference and its P.E.	56±5.3	72±4.6

TABLE III. *Comparison of the groups for the fifth trial of the right hand and the second trial of the left*

Group	Per cent doing better in 5th trial of right hand	Per cent doing better in 2nd trial of left hand	Number of cases
Normals	79	21	28
Stutterers	36	64	22
Observed difference and its P.E.	43±8.2	43±8.2	

TABLE IV. *Comparison of the two hands (fifth right hand trial and second left hand trial)*

Hand	Normals Per cent doing better	Stutterers Per cent doing better
Right (5th trial)	79	36
Left (2nd trial)	21	64
Observed difference and its P.E.	58±7.3	28±8.9

TABLE V. *Comparison of the groups in regard to mean times (first trials of two hands)*

Group	First trial Left hand Mean time in seconds	First trial Right hand Mean time in seconds	Number of cases
Normals	91.9	78.3	55
Stutterers	111.7	170.7	48
Observed difference and its P.E.	19.8±8.4	92.4±10.6	

TABLE VI. *Comparison of the two hands in regard to mean times (first trials)*

Hand	Normals Mean time in seconds	Stutterers Mean time in seconds
Left	91.9	111.7
Right	78.3	170.7
Observed difference and its P.E.	13.6±7.5	59.0±15.0

TABLE VII. *Comparison of groups in regard to mean times (fifth right hand trial and first left hand trial)*

Group	Fifth trial Right hand Mean time in seconds	Second trial Left hand Mean time in seconds	Number of cases
Normals	32.2	43.0	28
Stutterers	39.9	40.0	23
Observed difference and its P.E.	7.7±2.9	3.0±4.4	

TABLE VIII. *Comparison of the two hands in regard to mean times (fifth right hand trial and second left hand trial)*

Hand	Normals Mean time in seconds	Stutterers Mean time in seconds
Right hand (5th trial)	32.2	39.9
Left hand (2nd trial)	43.0	40.0
Observed difference and its P.E.	10.8±3.6	0.1

Conclusions

1. Right-handed stutterers are more facile with the left than with the right hand in mirror tracing, while right-handed normal speakers are more facile with the right than with the left.

2. There is a greater number of left-eyed individuals among right-handed stutterers than among right-handed normal speakers.

3. Normal speakers are genuinely superior to stutterers in mirror-tracing with the right hand and probably superior with the left also when we consider first trials for the two hands.

4. When we consider the fifth right-hand trials and the second left-hand trials the two groups are probably not significantly different.

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STANFORD MOTOR SKILLS UNIT [1]

BY

ROBERT HOLMES SEASHORE

The possibility of selecting individuals best suited for training or work in practical motor skills is dependent upon: (1) the adequacy of job analyses, (2) the nature and persistence of individual differences in such skills, and (3) a measuring technique adapted to conditions outside the laboratory.

The first step has therefore been an experimental analysis of eight serial motor performances on a group of fifty university men. (9) These tests ranged from speed of discriminative finger movement to accuracy in larger pursuit movements, and postural stability. The average inter-correlation of .25 indicates the specific nature of these performances and argues against the use of such terms as "general motor ability" or "general muscular coördination." For example, a person may rank consistently high on one skill such as a rotary pursuit arm movement at high speed and consistently low on others such as speed of turning a hand drill. Since the skills are independent it would be a mistake to say that a person showed "motor ability" because he ranked high on one or a group of motor tests.

When fifty men were rated for amount of training in typing, instrumental music, and competitive athletics, it was found that the correlations of these types of training with the score on the

[1] The construction of this battery of motor tests for personnel use outside of the laboratory is a result of a series of experiments on motor skills carried on by the writer while a National Research Council Fellow under the direction of Prof. Walter Miles. Previous studies have been: a summary of the literature on techniques for measuring serial action (8); the relation between speed in simple and serial action and certain verbal tests (10) (with Farnsworth and Tinker); and the interrelations and stability of serial motor performances.

The earlier studies of Prof. C. E. Seashore and his associates on this type of work in the Iowa Laboratory has served as a starting point for this unit.

A 16 mm. moving picture film of the unit is available for demonstration and inspection, and may be borrowed from the Stanford Psychology Laboratory.

battery of eight motor tests were slightly positive. However, it was found that men who were selected as being *very highly skilled* in instrumental music or athletics do tend to rate about 25 per cent (one-half a standard deviation) higher than the average unselected men. Apparently motor skills are obscured in the middle ranges by many other factors, and prediction at present should concern itself with the upper and lower extremes of a group.

In improving the efficiency of workers in highly skilled performances, the two methods: (a) selection of personnel, and (b) improvement of training and work methods must always be used together. This apparatus permits an evaluation of the importance of selecting individuals in different skilled lines of work. Even if no predictive value appears in specific instances, this finding would have a positive value in showing up the importance of work methods and conditions as a cause of individual differences in efficiency or progress in that type of performance.

The present data suggest that proficiency is quite specific for different serial performances but that the individual differences are quite stable on the different tests. Correlations of scores one day with scores forty-eight hours later gave reliabilities of .75 to .94 for the eight individual tests, with an average of .84 (not stepped up). This degree of stability or persistence should permit the use of these tests for predictive purposes, and the independence of the tests is statistically desirable in showing that a number of different sources are being tapped. Previous studies by the writer and others (7, 8, 9, 10) tend to indicate that individual differences in speed or accuracy of simpler reactions are not paralleled by differences in complex activities, even in relatively narrow sensory and muscular fields. From these experimental findings it follows that such variables as " general motor ability " and speed or steadiness in simple reactions are not suitable for the job analysis of complex skills. As a most conservative procedure it is suggested that a *sampling* of serial performances of the sort of neuromuscular coördinations involved in the skilled act would be the most likely device for predicting a practical motor skill. Such

a procedure is outlined in this description of a portable unit of motor tests.

From a survey of over twenty techniques for measuring serial action,(8) eight were selected as representative and suited for the previously described experiment, and six of these were subsequently adapted for use under actual working conditions. The tests which make up this battery are:

Tests [1]	*Type of Coördinations*
Koerth pursuit rotor.	Eye-hand coördination in following a target moving in a circular path at high speed.
Miles motility rotor.	Speed in turning a small hand drill.
Brown spool-packer (Seashore-Tinker modification).	Speed in a bi-manual coördination.
Motor rhythm.	Precision in following a regular rhythm pattern on a telegraph key.
Serial discrimeter.	Speed of finger movements in discriminative reaction to a visual series.
Tapping key.	Speed of forearm and finger movement on a telegraph key.

These performances involve principally visual, kinaesthetic and auditory stimuli, and overt movements of the forearm, hand and fingers. Each test has a single integrated score, and all but the spool-packer, which is very simple, are scored automatically by counters.

The unit is designed to be independent of highly technical instruments and laboratory facilities and to be usable under the ordinary working conditions of industry, office or school. The tests have all been tried out in laboratories and found to be practical in their operation. Data on them are available in most cases from their original descriptions. In addition, all of the

[1] The writer is indebted to Prof. Warner Brown, Dr. Wilhelmine Koerth and Prof. Walter Miles for permission to use their tests in this assembled unit.

tests have been used as a battery by the writer, thus affording further results.

The six tests should be completed in a little less than two hours. While they may be given by the usual method of completing each test before starting the next, the writer has found it valuable from a number of standpoints to use the Miles cycle plan of testing.(4) By this method three cycles are used, each cycle taking approximately thirty-five minutes. The number of trials per cycle and for the entire test are given in Table I.

TABLE I. *Distribution of trials in cycle method of using motor skills tests*

Test	Length of trial	No. trials per cycle	Total No. of trials
Koerth pursuit rotor.....	20 rev. (once per sec.)	10	30
Motor rhythm	1 min.	3	9
Tapping key	5 sec.	3	9
Serial discrimeter	2 min.	3	9
Miles speed drill.....	10 sec.	3	9
Brown spool packer.....	3 min.	1	3

Among the possible uses in industry are: (1) the selection of workers for training in manual skills, provided that experience has shown that a reasonable amount of training still leaves large differences in that type of skill, and that lack of success is not due to social or mechanical difficulties; (2) the study of accident rates in industry and transportation, as far as motor skills may be involved in the handling of machinery; (3) possible indirect uses such as for studies on ventilation and other working conditions and (4) to provide data to be used in connection with other ratings, interviews, etc., to determine the direction of interests which individuals have developed. There are probably as many or more applications for theoretical investigations in laboratories and class rooms.

The unit is so arranged[2] as to use the same apparatus for several different tests and to occupy a small amount of space for convenience and portability in school and industrial use. As shown in Fig. 1, the apparatus is placed on a baseboard 1 inch

[2] The different tests are easily detached from the main baseboard and can be used separately by several experimenters working at the same time where it is advantageous to get quick results.

by 23 inches by 25 inches, reinforced by two 1 inch by 4 inch slats. The switchboard, counter, and Brown spool-packer occupy one of the long sides, A, in Fig. 1.

Three of the tests use the same batteries and Hollerith counter, and are controlled by the three switches. The motor rhythm circuits are the most complicated, but with slight changes they serve for the tapping and pursuit tests, also, the motor rhythm and pursuit tests use the same phonograph motor. The remaining tests are independent and nonelectrical.

The coverbox, 18 inches high, fits *around* the edges of the baseboard, and in transportation is connected to the baseboard by four hinges. These are attached underneath the baseboard and inside the coverbox and the hinges are held together by a removable copper pin. All of the wood construction is screwed together, and the hinges bolted to wood. This coverbox serves also as a table of adjustable height upon which the unit is placed for operation.

To set up the unit for working, the crank of the phonograph motor is secured in place, the speed drill socket arm is extended out about 6 inches over the board (see B in Fig. 1) and the weight string of the serial discrimeter placed over the pulley on the drill socket arm. The telegraph key and sounder are placed on a table some distance away, in a position so that the observer will have his back to the unit. All three switches are kept open at all times except when their separate tests are actually in use.

All of the tests except the Brown spool-packer are scored automatically by counters. It is necessary to read only the counter dial at the beginning and end of the performance and record the difference on a printed form. A stop watch is used to time start and stop signals.

General Instructions

To the Experimenter:

The first essential in handling this unit is to practice the giving of instructions and handling of apparatus as outlined until you have standardized your own performance so that these conditions will be the same for each person whom you test. It is advisable

to go over the performance by yourself until you are familiar with it, and to try it out on at least four or five persons before beginning actual work. Aside from this factor, experimental controls are the same as for any experiment. Always give full instructions with demonstrations before starting a test, to minimize problem solving and emphasize skill in actual performance. Have the observer demonstrate in outline the performance he is to do and check before starting. Allow no practice trials other than this outline performance.

To the Observer:

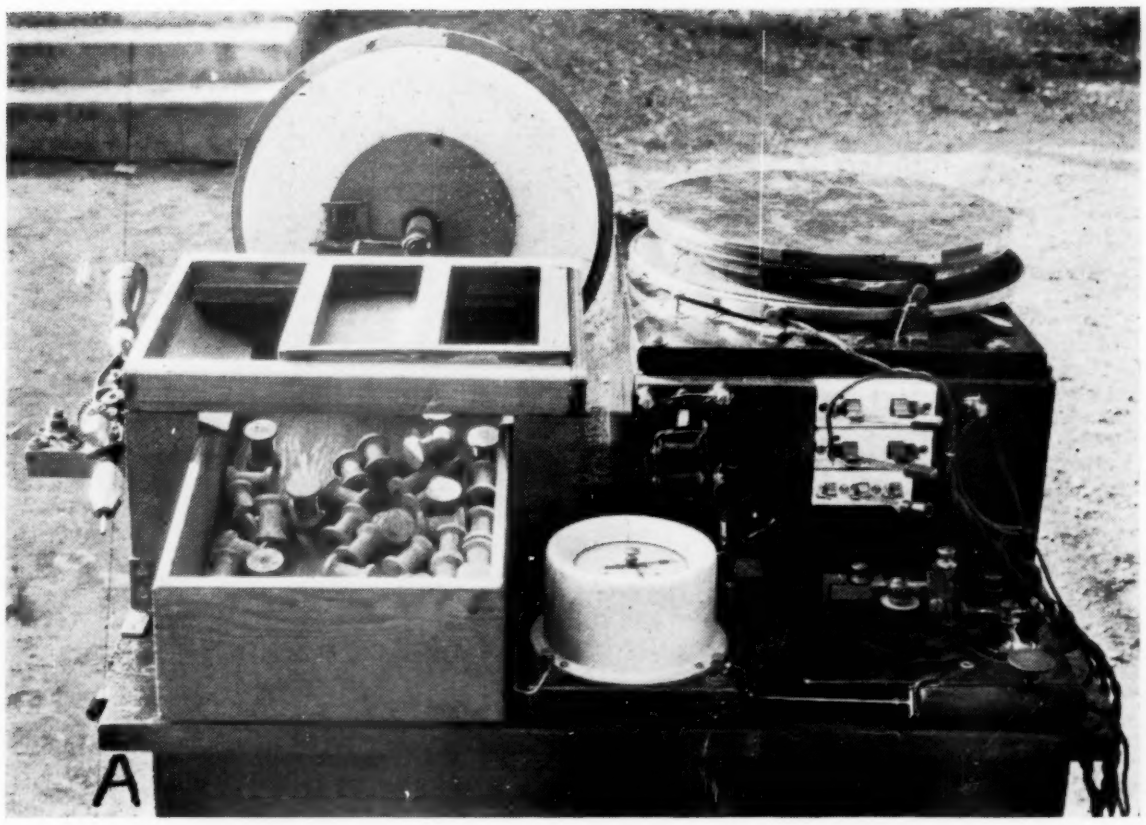
The aim of these tests is to measure individual differences in skill of doing six performances, to see if the persons who score highest on these tests will also do the best work in practical lines of skill. You will be given your scores as we go along, and you will always be instructed how to do each test, so that it is not a puzzle but a measure of accuracy and speed of performance. The six tests will take about two hours to complete. In order to do these tests in that time it will be necessary to shift rapidly from one apparatus to the next and to work as hard for good scores as you would in an athletic contest. You may ask any questions you wish about the tests.

Construction and Operation of Apparatus [3]

A. The Koerth Pursuit Rotor (see B, Fig. 2)

1. Materials: Double spring Victrola motor or any standard double spring motor, cost $30 with the turntable and board; ply-board box 11¼ inches by 15½ inches and 8 inches high (for mounting phonograph unit) with room inside for two sets of three batteries each. Pursuit disc of wood or bakelite with silver target and contacts imbedded as in drawing; flexible pointer with hollow wooden handle, 1 inch diameter and 5 inches long with 1/16 inch brass rod hinged to handle for free movement. Brass rod 5 inches long with 1 inch bent over at right angles at the end. Flexible wire is drawn through the hollow wooden handle and soldered to brass rod leaving the hinge free moving. (Hollerith

[3] Original descriptions are listed under respective names in references at end of paper.



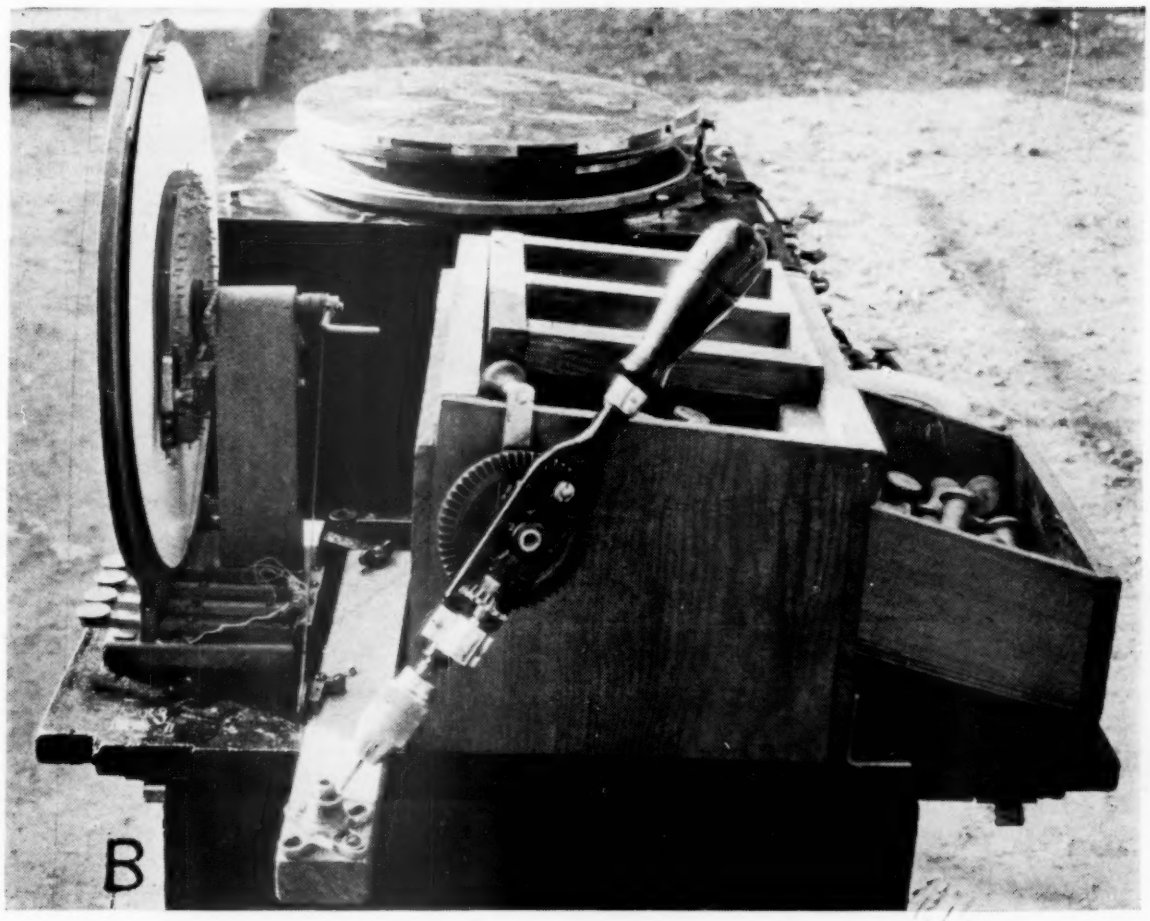


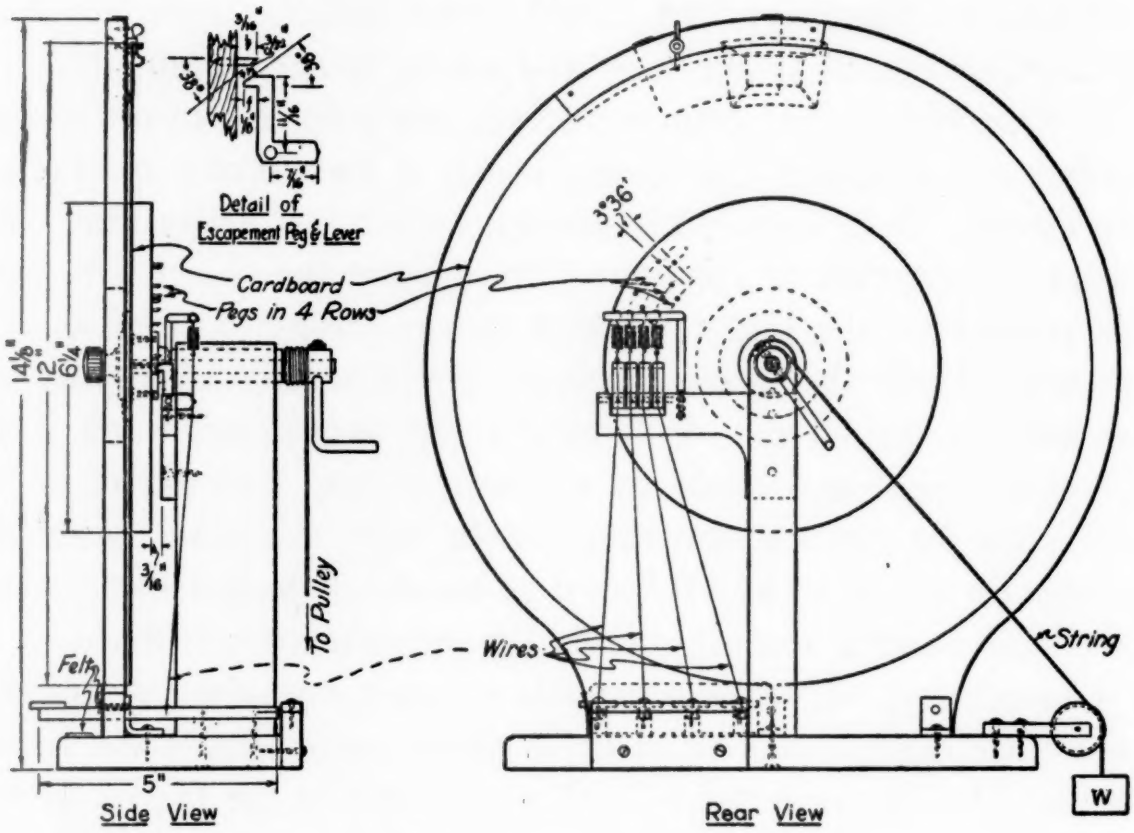
FIGURE 1 shows views of the Stanford Motor Skills Unit. *A* shows the Brown spool-packer, the electric counter and switchboard in the foreground. The subject would face the Brown spool-packer as the reader does this picture. *B*, the four keys of the Serial Discrimeter are shown at the left, the speed drill with the metal socket mounted on an extension arm is in the immediate foreground.

dial counter, Catalogue No. 22407, price $22.50, from Stoelting & Co., Chicago, Ill.) Batteries and wiring as in diagram.

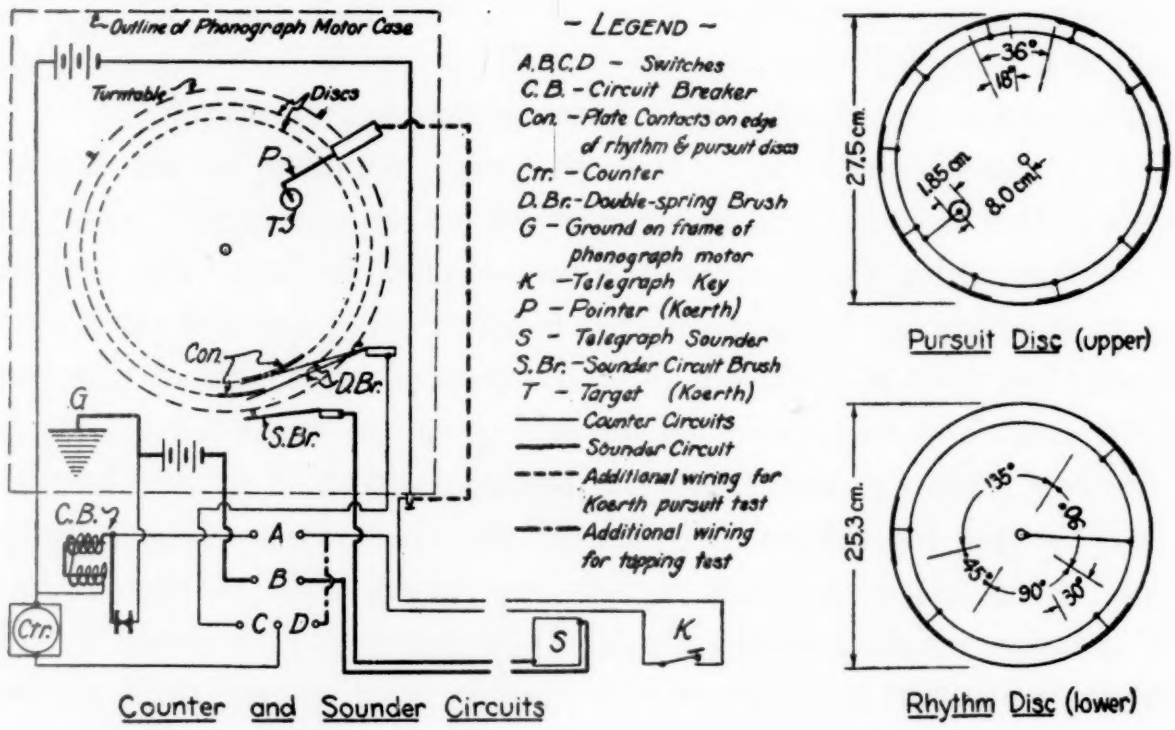
2. Operation: The counter records one point each time a plate contact passes under the spring brush if the pointer is kept on the target. It is controlled through switch C. Directions: Instruct the observer as follows: "In this test the object is to keep the pointer on the target while it moves around a circle once a second. Hold the pointer handle horizontally and lightly on account of the hinge. You cannot put any pressure on it by pressing down; and to do so will only cramp your wrist. You will start the phonograph motor with your left hand, place the pointer on the target and follow it as accurately as possible. After you have started several rounds the experimenter will throw in the switch and when the pointer is on the target the counter will click once every time one of these plates passes under the spring brush. The experimenter will tell you to stop at the end of twenty rounds. It is possible to make ten points per round, or 200 for the twenty rounds but everyone starts low at first and then learns rapidly. Hold your elbow away from your side for a free swing and rest your left hand on the box if you wish." (Demonstrate performance and check any of his mistakes before starting.)

3. Precautions: (a) Time the disc rotation to 60 r.p.m. (b) Polish pointer[4] end and target with "crocus cloth" abrasive (obtained at hardware stores) at end of each 5 trials. (c) Adjust tension of spring brush so that it touches every contact plate as it passes but does not prevent pick up of speed. (d) Have observer hold end of pointer wire in vertical position to avoid getting a sidewise pressure; also check horizontal position of pointer handle. (e) To test for proper working of circuit move a contact under the spring brush and tap lightly on target with pointer to see if counter registers accurately. (f) In starting, give ready signal, allow subject to go four or five rounds until phonograph attains full speed, then throw in switch C as the target passes the spring brush, count silently 20 rounds, throw out switch C at end of 20th round and give stop signal. Rest 30 seconds between trials.

[4] Use silver for pointer tip and plates of both pursuit and rhythm discs.



SERIAL DESCRIMETER



Counter and Sounder Circuits

Pursuit Disc (upper)

Rhythm Disc (lower)

MOTOR RHYTHM, KOERTH PURSUIT AND TAPPING TESTS

FIGURE 2. Working diagrams for four of the tests described. *A*, side and rear views of the Serial Discrimeter. *B*, Details for the Motor Rhythm, Koerth Pursuit and Tapping Tests.

B. Motor Rhythm Synchrometer

1. Materials: (See B, Fig. 2.) Uses the same phonograph unit, batteries, and counter as for the pursuit rotor and has in addition a doorbell circuit breaker and wooden disc (illustrated) on the counter circuit which is operated by a telegraph key. A separate set of three batteries and telegraph sounder are operated through ⅛ inch brass studs screwed into phonograph turntable and passing under the single spring brush (illustrated). Telegraph sounder and key unit (No. 25515) also obtainable from Stoelting & Co. of Chicago, price $4.50. The wiring is the principal feature and is illustrated completely. The circuit breaker is constructed from an ordinary small size double magnet doorbell by removing the bell and its supporting arm, clipping off the vibrator spring in order to produce only single strokes of the arm and wiring the doorbell as follows: Attach one wire to regular binding post on the armature side of the bell, and the other wire to the small set screw half way down the same side, which regulates the amount of throw of the arm, and extend a small flexible wire from this point to the arm itself. Tungsten points for Ford coil, price 15 cents, are cut down in size and one point soldered to arm of doorbell and the other screwed to a supporting block placed opposite the arm. A small coiled spring prevents the doorbell arm from starting its stroke as rapidly as does the Hollerith counter. The principles of operation are as follows: The sounder is operated by the passage of the brass studs under the single spring brush and is controlled by switch B. Both the sounder and counter circuits are grounded to the frame of the phonograph motor by one of its bolts. The counter circuit operates as follows: The telegraph key is directly connected on one side with the battery; from here the current passes through the rhythm disc, the double spring brush, the circuit breaker, and switches C and A to the counter, from which the circuit is completed directly to the batteries. If switch C is closed the telegraph key will work the circuit breaker at all times. If switch A is also closed the key will also work the counter, but only if the key is tapped while one of the rhythm disc contact plates is passing under the double spring brush. This device is necessary to pre-

vent scoring by merely tapping ahead of time and holding the key down until the contact passes under the brush. The reason for this action is that the circuit breaker is slowed up in its action very slightly by the coiled spring attached to its arm, and since the counter is of about the same speed of action, this very slight advantage enables the counter to work before the circuit is broken, provided a contact plate is under the double spring brush. The tension of the spring should be adjusted so that the counter will work positively when the rhythm disc is stopped in position for tapping, but will not work if the spring is slacked a little from this position. This adjustment is a relative one, depending upon the type of circuit breaker and counter used. The disc contact plates are set so that when the center of the sounder contact is made, the disc contact center will be 6 degrees behind the center of its brush. This allows for the fact that the latent time of the sounder is approximately .01 second, and the observers tapping lags behind by that amount. At 50 r.p.m. the width of contact plate used will limit the number of taps made to those within .025 seconds before or after the time when the sounder tap is heard.

2. Operation: Demonstrate performance to observer as follows: "In this test you are to tap exactly in time with this telegraph sounder. It will sound these four notes over and over again (illustrate) and it will always be the same. You are to hold the telegraph key in this manner (illustrate) so that your first finger is on top of the key and it is held between the thumb and second finger. Your score will be the number of taps which are right within .05 second of the exact time of the sounder. Each trial will last one minute and you do three trials with short rests in between. You are to start tapping when the sounder does, and stop when it does. You will be allowed a few rounds in which to get started each time before your score begins on the counter. Remember to keep exactly in time with the sounder, just as you would in an orchestra."

3. Precautions: (a) Polish points[5] of the telegraph key after each two trials. (b) Tension of double spring brush should be

[5] Keep points of key adjusted 1 mm. apart.

light enough to allow speed in pick-up of phonograph motor, but strong enough to make good contact with all of the plates. (c) Polish the tungsten points on circuit breaker once every four trials. (d) Keep all binding posts on telegraph key, sounder, and counter tightened; also the nut which holds the Hollerith counter hand. (e) Always have the observer hold the key, not tap with his fingers. This is necessary because of better contacts made this way and also because otherwise the finger would raise to different heights above the key for intensity differences which the observers often make in the pattern. (f) Rhythm disc should always be set so that the center of the disc contact reaches the center of its spring brush 6 degrees later than the center of the sounder contact is made. Both pursuit and rhythm discs should be held by a thumb screw inserted into the center part of the table. (g) Time disc to 50 r.p.m.

C. Serial Discrimeter

1. Construction: (Shown in A, Fig. 2.) In this test a simple escapement mechanism releases a peg on a circular disc each time the correct one of four keys is pressed. The signal for the key is given at a small window and as soon as the correct reaction is made the next one appears automatically. The steel pegs are of 1/16 inch rod and the escapement is of brass. The driving weight is two pounds. The stimuli used were numbers 3/8 inch high, 1, 2, 3, and 4, made by Bates Numbering Machine, style E.

2. Operation: The test starts always where the subject left off the previous time. Rewind after each 5 trials. Adjust paper disc so that when the machine is under tension the signal will be in the center of the window. The thumbscrew at the center of the apparatus adjusts this and must be very tight before using. Depress all four keys and wind up weight spring on crank shaft so that when completely wound the weight will be nearly up to the table and there will be a double layer of string around the shaft. Care must be taken to keep the crank oiled and to avoid pressing down more than one key at a time. All four escapement levers should be adjusted to a point 1/16 of an inch away from the disc.

Demonstrate to observer, having him use the four fingers of the right hand. Instructions: "In this test you are to press one of four keys as soon as you see the signal at the window. Nothing will happen unless you press the correct key, but when it is pressed the next signal will appear automatically. You will keep on as fast as you can for two minutes. Mistakes do not count except that it takes time to make mistakes and your score will be the number of correct reactions in two minutes. There will be two consecutive trials. *Never press more than one key at a time.*"

3. Precautions: Occasionally persons will tend to press two keys at once consistently. This should be warned against. Observers must also be warned never to depress all four keys at once except for winding, when experimenter will ask for it.

D. The Tapping Test

In this test the telegraph key batteries and counter are controlled through switch D (see B, Fig. 2). Trials are for five seconds each, and if considerable accuracy is needed the metronome timer used by Ream should be used. A stop watch is less accurate but is permissible because of the extent of the individual differences, if enough trials are used.

1. Operation: Show observer how to hold key, the same as in the rhythm test with key held between thumb and second finger, and the first finger on top of the key. Check his performance as follows: "This test is to measure the speed of tapping the telegraph key as fast as you can for a period of five seconds. You will hold the key between the thumb and the second finger with the first finger on top as before. Take a position with your feet firmly on the ground, body leaned slightly forward and forearm free of the table. I will say 'ready' and 'go' at this rate (demonstrate one second interval between signals) and you will start tapping at the signal 'go.' I will then time you for five seconds by the use of the stop watch and switch and tell you when to stop. Do not get rigid but work for speed."

2. Precautions: Keep telegraph key contacts shined at the end of each fourth trial. Test for accuracy of counter registration by

slow tapping before the test. Practice the synchronous operation of stop watch and switch to get exactly five seconds.

E. The Brown Spool-Packer

1. Construction: shown in Fig. 3.

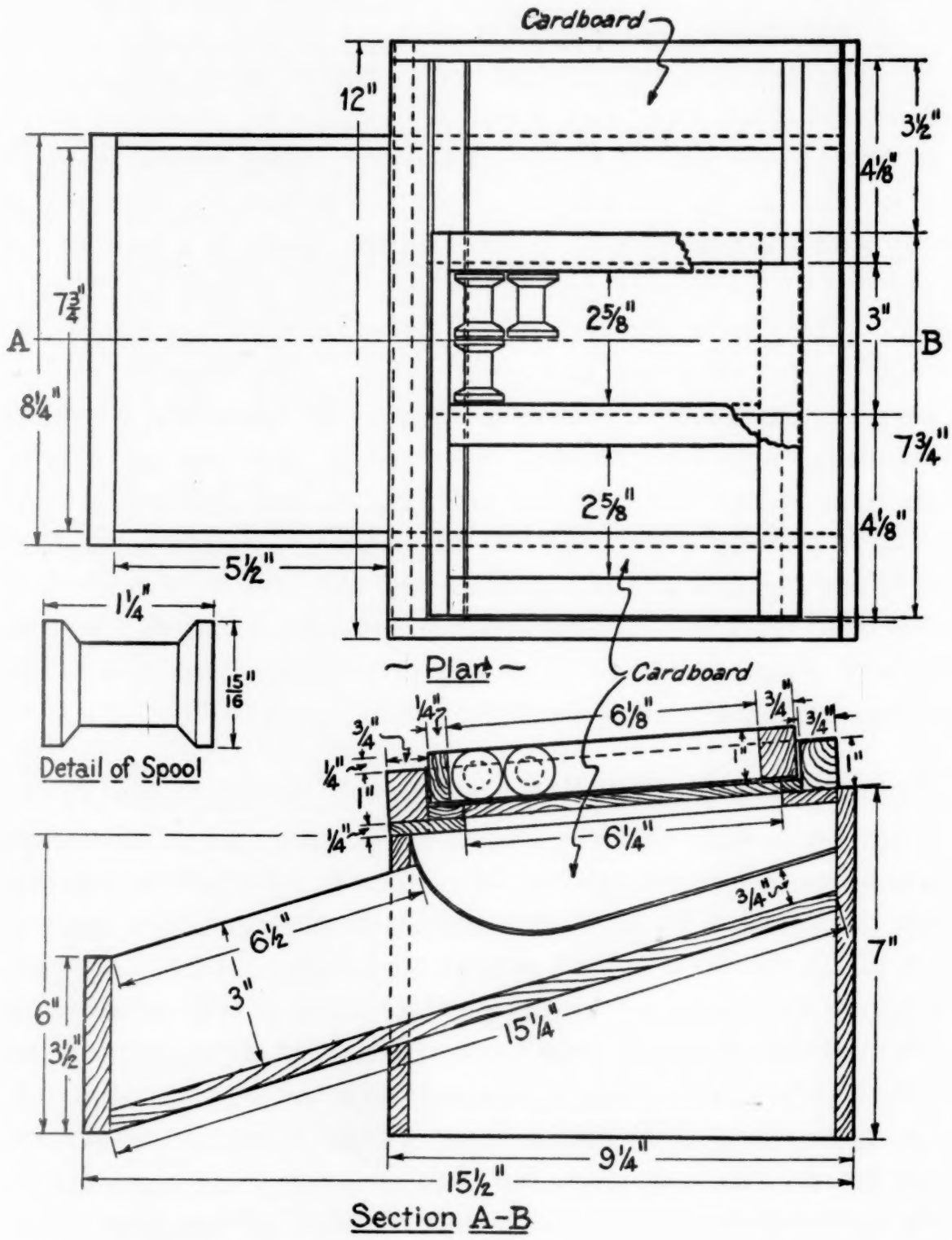
2. Operation: Start the test with 'ready' and 'go' signals one second apart using stop watch for timing the period of three minutes. Move sliding frame with quick, sharp motion as each box is filled so that it will be in position before the observer is ready with the next spools. Start with the spools in a heap at the lower end of the hopper and hands just ready to pick up the first spools. Mark tally lines on a pad of paper for each box completed, record number of boxes and extra spools. Demonstrate the following instructions: "This is a measure of speed and accuracy in working with two hands. You are to pick one spool with each hand, place them in the box end to end and repeat this operation packing the box as fast as possible. Always work your two hands together and if you make any mistakes fix them before going any further. The spools are removed from the box in this way (demonstrate). You will keep packing the spools for three minutes and your score is the number packed."

F. The Miles Motility Rotor, see description by Miles.(6)

This hand drill (Millers Falls No. 1, price $2 at hardware stores) has a Veeder counter No. 4 D 8 (revolution counter, shaft on left, top of shaft turning from observer, five figures, price $2.25, Veeder Mfg. Co., Hartford, Conn.) A small sixteen-pitch gear having a ¼ inch hole and 14 teeth (other numbers of teeth may also be used) runs the counter from the small gear on the hand drill. The counter is mounted on the frame of the drill by a small fiber block and a brass clamp running underneath. A socket in which to place the drill is made of a brass block, with ¼ inch hole, ⅜ inch deep with rounded bottom, kept oiled.

2. Operation: Demonstrate to observer and check performance. Give "ready," "go" and "stop" signals to time ten seconds. Watch for failure to stop on time. Start and stop should be exactly on signal. Instructions are as follows: "This

is a speed drill. The counter on it shows the number of units turned up during periods of ten seconds. You are to hold it in this position (demonstrate—drill approximately vertical and



BROWN SPOOL-PACKING APPARATUS

FIGURE 3. Working diagrams for the Brown Spool-Packing apparatus as modified by Seashore and Tinker.

inserted in the oiled socket, right arm at *right angles to plane of large gear wheel* and handle turned by a rotary motion of the forearm, fingers, and wrist.) This has been found superior to the ordinary method of turning. You will work by ten-second trials starting at the signal ' go ' and stopping short at the signal ' stop.' Always start with the handle straight up. Take a good firm position, feet fairly wide apart and do not try to do it all on one breath. A smooth movement will aid your speed by avoiding sharp jerks which may loosen your hold on the handle. Grasp the handle *between* the first three fingers."

Summary

1. From an analysis of eight serial motor performances given intensively to 50 university men, it was found that the average intercorrelation was .25.

2. The correlations were only slightly positive for the 50 men on scores for the eight motor tests and training in typing, instrumental music and competitive athletics.

3. Motor skills are obscured in the middle ranges by many factors and prediction at present should be confined to the upper and lower extremes of a group.

4. The reliabilities of the motor tests ranged from .75 to .94, with an average of .84.

5. The cycle method of testing used extensively by Miles has proven of value in the giving of routine motor tests.

6. A group of six motor tests were combined into a compact transportable unit which is suitable for use in school and factory as well as in laboratory work. Complete details with working drawings for the construction and operation of this unit are supplied.

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THE SENSE OF DIRECTION IN MENTAL IMAGERY.

BY

CARL I. ERICKSON

When one listens to a speaker (or reader) describe a situation not present to the senses he may be directed to note certain spatial relations among the objects and persons referred to. He may be more or less effectively guided as to directions and distances either by appropriate verbal terms or by use of gesture or by both methods together. But when no specific reference to direction or distance is made he may then create his own imagined settings wherein the spatial patterns of direction and distance may play a meaningful part. In any case it seems worth while to determine how well a listener observes or uses the spatial references as given by a speaker, and also how he creates his own spatial patterns when left to his own devices. This study is concerned primarily with the latter problem although the data obtained also have some bearing on the former.

The subjects used in this study include two groups of college students. Group A consists of three classes in experimental psychology with a combined enrollment of 43 students. Group B consists of 42 students in elementary psychology. The writer read to each class separately the first paragraph of O. W. Holmes' "Revelations of a Stone," and the second paragraph of G. W. Cable's "Mary's Night Ride."[1] These paragraphs will be referred to as Part I and Part II, respectively. In Part I the listener is expected to participate in the scene portrayed, as indicated in the first sentence, "Did you never, in walking in the fields, come across a large flat stone, . . . and have you not . . . insinuated your stick or your foot or your fingers under

[1] These paragraphs were read as presented in a book of readings entitled "The Psychological Development of Expression," Vol. I, compiled by Mary A. Blood and Ida M. Riley.

its edges and turned it over . . . ?" In Part II the listener is expected to be only a witness of what is portrayed. The first sentence reads, "About the middle of the night Mary Richling was sitting very still and upright on a large, dark horse that stood champing his Mexican bit in the black shadow of a great oak." No directions are referred to except that several objects are located as right or left or in front of certain points of reference.

Each part was so read as to make the meaning as clear as possible. No gestures were used at any time. Just before each paragraph was read the subjects were told to listen carefully and to create a vivid mental picture of all that was presented so that later they could reproduce the whole of it in detail. Reproduction of Part I was called for immediately after the reading. This was done partly to justify the request that had been made and partly to secure good attention for the reading to follow. Nothing was said in the instructions about either direction or distance but since the subjects were questioned about both of these factors after hearing Part I special attention may have been given to them during the reading of Part II. The whole procedure would necessarily cause the subjects to be more attentive and critical during the readings than a typical audience would be.

Immediately after the reproduction of Part I the following question (1) was put, "What direction did you seem to face as you began walking toward the stone?" After the reading of Part II a similar question (2) was asked: "What direction did you seem to face when you were imagining the scene that was described?" After certain other questions had been asked the last question (3) put to each group was, "What direction do you seem to face in this classroom, *i.e.*, what direction do you seem to face when you look toward the front of the room?" The cardinal points and the four mid-points were used in designating the answers to the three questions.

Table I shows the results from question (3) and also the relation between these results and those obtained from questions (1) and (2). Groups A and B are considered separately since the classes that make up group A each faced north in the classroom and group B faced west. The figures express percentages

TABLE I. *Relative frequency of the different directions as they appear to the subjects in the classroom and the number who continue to face these directions in Part I and Part II*

	Classroom		Part I		Part II	
	A	B	A	B	A	B
North	56.1	40.5	8.7	5.9	43.5	35.3
West	14.6	45.2	50.	21.	50.	36.8
South	9.7	7.1	25.	0	50.	33.3
East	7.3	0	0	..	0	..
Northeast	4.9	0	50.	..	50.	..
Northwest	7.3	5.7	33.3	50.	0	50.
Southwest	0	2.4	..	0	..	0
Southeast	0	0	..	..	..	..

and are computed from the number of responses that could be tabulated. In any case, not more than three responses were omitted or were too ambiguous to classify.

Columns two and three of Table I are of interest in connection with general orientation. Approximately only one-half of the subjects, 56.1 per cent in group A and 45.2 per cent in group B, are correctly oriented in the classroom as far as points on the compass are concerned and a few are badly "turned around." Those who do not seem to face the true direction have greater preference for either north or west. This is especially true in group B where 40.5 per cent appear to face north which is almost as many as appear to face west, the true direction.

Comparing the classroom results with those of parts I and II, it is evident that the direction in the classroom is not always the direction in the imaginal experience. Were the orientation the same in each case then the percentages for parts I and II would all be 100. But we find instead that no percentage is over 50 and several are zero although the latter apply to only small numbers of subjects. In the largest single division, which includes 56.1 per cent of group A, only 8.7 per cent retain their classroom orientation in part I. In part II the corresponding percentages are distinctly larger. The extent of difference between the various situations is more clearly pointed out in Table II where the amount of shifting is specified.

Several points of interest are revealed in Table II. (1) While the least shifting takes place in part II, even here at least 58.5 per cent shift 45° or more from their classroom orientation.

TABLE II. *The extent of shifting from the classroom directions to the directions experienced in Parts I and II. Figures express percentages*

	No Shifting		45°		90°		Over 90°	
	A	B	A	B	A	B	A	B
Part I.....	21.	15.	18.4	27.5	44.7	27.5	15.8	30.
Part II.....	41.5	41.	17.1	17.9	26.8	30.8	14.6	10.3

Viewing the results of both Tables I and II, it may be said that when a group of listeners respond imaginally to the verbal description of a situation, from 50 per cent to 75 per cent or more will assume a different direction from that which they appear to face at the time. (2) The two groups, although facing different directions, have reacted very much the same, the similarity being especially marked in Part II. It appears then that the amount of shifting is quite independent of the true direction faced. The results for groups facing south or east would probably be very much the same as those obtained for north and west. (3) The amount of shifting in Part I is quite different from that in Part II. It may be inferred from this that the spatial adjustment of the listener varies with the type of experience presented. (4) The various subjects differ widely in the extent to which they are caused to shift from their actual orientation in their immediate surroundings. The individual character of the adjustment is further shown in this study in two ways, the first of which probably has some bearing upon the second: (a) 65 per cent of the subjects stated, in response to a question, that the scene pictured in Part I was more or less similar to one experienced before; and it is quite probable that none of the 35 per cent were wholly unaffected by relevant experiences of the past. (b) In estimating distances between the subject himself and some object included in the imaginal experience the following ranges of estimate were recorded: Part I—one foot to 150 yards; Part II —five feet to one mile. Obviously considerable variation in orientation is the rule where the subject makes his imagined spatial adjustments unaided.

How gestures designating spatial relations would have affected the foregoing results one can only conjecture. But here again a set of responses from the subjects is very suggestive. In response

to the question, " Would gestures have helped you in forming a clearer mental picture of the situation presented? " 79 per cent stated unequivocally that gestures would not have helped, and approximately 25 per cent volunteered explanations to the effect that gestures would only have been distracting or confusing to them. This strongly suggests that when a speaker desires to secure from his audience a clear conception of what he describes he should, if possible, refrain from the use of gesture (of the demonstrative type) and allow his listeners to create their own spatial patterns. At least one might infer from this study that a listener's response in an imaginal situation will be most effective as his sense of direction is most freely expressed.

THE IOWA STATE COLLEGE REASONING TEST [1]

BY

THOMAS F. VANCE

In order to arrive at the point of this paper on the subject, " The Iowa State College Reasoning Test," it is necessary to describe briefly the other tests of which it is one in the series.

The psychological test which has been given this year to the Freshman class of Iowa State College is a modified Alpha. The Alpha was chosen as a basis on which to construct a new form for the reason that it has given consistently higher correlations than it has been possible to secure with any other test. In the modified form, Arithmetic, the Synonym and Antonym, the Disarranged Sentence, the Number Series, the Analogies and the Information tests remain very much the same as they appeared in the original form. The easier exercises at the beginning of each of these tests have been advanced to the bottom of the preceding page to serve in the capacity of fore-exercises which gives the student a preliminary practice before beginning the test proper (after the fashion of the National Intelligence Test). More difficult exercises were added toward the close of each test with the purpose of making the series more difficult.

The Information test was changed as follows: The options were increased to five, each was numbered, and the student required to write the number of his choice on the line to the right. A number of questions bearing more directly upon general lines of information which a high school might be expected to offer were substituted for some of the easier ones in the old test.

The old test has been converted into a reading test. The familiar circles, triangles, etc., appear somewhat as they do in the old form but they are printed to the right and the directions immediately to the left. Instead of the directions being read to

[1] Read before the Iowa Academy of Science, Cedar Rapids, April 30, 1925.

the student, he reads them and carries them out as he reads. Two exercises have been added to this test.

Test 3 has been eliminated entirely.

The Reasoning test has been added. The exercises are for the most part cast into the syllogistic form. The following are representatives:

1. Texas is north of Mexico. The Rio Grande separates Texas from Mexico. What direction is the Rio Grande River from Texas? (1) North, (2) South, (3) West, (4) insufficient data.

2. Suppose that fir were harder than oak and oak harder than walnut. Which would be the hardest? (1) Fir, (2) Oak, (3) Walnut, (4) insufficient data.

Full directions were given with the fore-exercises.

To summarize the tests in the series:

1. Following directions	14 points
2. Arithmetic	20 points
3. Synonym and antonym	35 points
4. Disarranged sentences	24 points
5. Number series completion	20 points
6. Analogies	40 points
7. Information	40 points
8. Reasoning	35 points
Total number of points	228 points

It may be said, parenthetically, that the test is more difficult than the Alpha, the median being approximately twenty points lower. Its value in predicting achievement in college appears to be no better and no worse than the old Alpha. The correlation of the present test with first quarter average in the group of science students which may be taken as an illustration in this report is .52, lower than that given by the Alpha with this division by .07.

The accompanying table contains the simple correlations between each of the eight tests and every other and each of the tests and academic standing as measured by the grade average for the first quarter.

It is to be observed in the table that Tests 4 and 6 tie for first place in correlating with college average, Test 7 following in second place; but Test 8, the Reasoning test, falling second from

TABLE I. *Correlation table—139 industrial science students, 1925*

Tests	2	3	4	5	6	7	8	Av.
1.....	.49	.48	.39	.51	.54	.46	.67	.33
2.....		.31	.21	.50	.47	.39	.47	.32
3.....			.43	.45	.51	.59	.31	.36
4.....				.39	.39	.50	.36	.43
5.....					.49	.45	.13	.19
6.....						.53	.49	.43
7.....							.48	.38
8.....								.26

the bottom. The r. of .26 compared with .52, the r. of the eight tests combined with college average, indicates that Test 8 has very little value for predicting success in college.

The correlation array of the intelligence examination as a whole with college averages shows a closer relationship in the highest quartile than in any other part of the range. In the middle quartiles the relation is practically zero, becoming somewhat better in the lowest quartile. The method of grading may have some effect upon the correlation. There are but two grades below the passing mark of 75, "C" and "NP." In making out the averages the registrar computes these as 60 per cent and 40 per cent, respectively. A unit above the passing mark becomes from fifteen to twenty times as great below the passing mark. A more uniform scale of grading in the lower levels might give a more normal distribution and tend to increase the size of the correlation.

Correlations are sensitive instruments, and may sometimes disguise a relationship in certain parts of the series which are after all significant, and so it seems advisable to express the relationship in other terms, as, for instance, the percentage of measures in the one series that equals or exceeds certain points in the other. Using this method of comparison, it is found that:

Forty per cent of the students in the highest quartile in the intelligence series have a college average of 90 per cent or above.

Eighty-six per cent of the students in the highest quartile have a college average of 82½ or above, which is the average of college grades.

In the lowest quartile of the intelligence series, 60 per cent fail to reach the passing mark of 75.

In the lowest quartile of the intelligence series, 91 per cent fail to reach 82½ per cent, the average of college grades.

Using the same method of comparing the scores on the reasoning test with college averages, it is observed that 34 per cent of the students in the upper quartile make an average college grade of 90 or above, while 60 per cent are at or below 82½, the average of college grades.

In the lowest quartile of the reasoning scores 43 per cent are below the passing average of 75.

Viewed from this angle, the Reasoning test does not measure up as a means of predicting success in the college career, at least not in the early stages of that career.

Of the various combinations of multiples it is apparent that the Reasoning test neither adds to nor detracts a great deal from the size of the correlations. No possible correlation by the multiple method gives a higher figure than .52, which is the simple correlation between the sum of the eight tests and college average. It would seem that the entire load of this combination is carried by Tests 4 and 6, since they together correlate with the average at exactly the same value, .52. This would indicate that the series of tests could be reduced from eight to two and be as satisfactory for predicting college standing.

This illustrative data leads up to the question which is the main issue of this discussion: "Are schools and colleges training the young to reason?"

If schools, particularly colleges, fail in this all important function of teaching pupils to reason, they fail fundamentally. Indeed, they have sold themselves to the tax-supporting public on this very point. The new subjects introduced into the curriculum are given a place for the most part because of the promise which they offer to stimulate thinking. Instructors quite generally resent the implication that they are teaching "skill" or "memory" subjects rather than "thought" subjects. Departments of education are featuring the problem method of instruction with the belief that it stimulates thinking. Places of leadership can be filled adequately only by people who think and by people who think clearly. That people do go into places of leadership from college does not necessarily mean that the college has trained them to reason.

The natural gift with which they are endowed may be sufficient to carry them through.

There is no question before the educational world of any greater importance. But how can we know to what extent we are getting on toward its solution? The long years of speculation still leave the question unanswered. One of the necessary steps in the experimental attack on the problem is the perfection of a reasoning test. Such a test will not be a simple test, it will involve a variety of exercises each of which will demand something more than memory, sensory perception, and the like; it will be a measure of the capacity to "catch on," figuratively speaking, and to ferret out hidden meanings. Performance tests should play a rôle as well as those of the linguistic type.

Syllogistic tests such as we have been describing would seem, naturally, to have a place in such a series. It correlates only to a small degree with college averages, but so also does the Arithmetic test. Not any of the series correlates very significantly, yet four of them must involve reasoning to some considerable extent. Test 8 correlates .38 with first quarter grades in mathematics, .12 higher than with college averages.

Of course, the particular Reasoning test is not perfect; no test is. One who still has some faith in it may be permitted to question very seriously whether colleges are even beginning to utilize the function of reasoning to anywhere near its limits. He may further question whether college grades are influenced much by thinking on the part of the student even when it shows itself in the classroom. It is not difficult to find numerous illustrations from the classroom where originality is discouraged rather than stimulated.

The vistas opening from this preliminary study are interesting. The testing of the validity of reasoning tests themselves by checking them with those aspects of certain college subjects which do without question demand reasoning, *e.g.*, correlating the test with grades made by students in an original project in physics, or chemistry, where objective methods of scoring have been devised, is one of the immediate problems of this study. The improved reasoning test will be correlated with the college standings from

the Freshman to the Senior year. If students are being trained to reason, it should show itself in larger amounts and in better quality in the Senior class than in the Freshman class.

There is, of course, the possibility, if not the probability, that the results of such a study will not be conclusive. Even so, the effort promises to be practical and worth while. One of the greatest values of intelligence testing is to be found in the stimulus that is given both to instructor and to student to measure up to and to excel the rating set by the tests and to the construction and maintenance of standards in the several lines of work. An analysis of subject matter and methods of teaching such as this study will entail will focalize the attention of instructors upon the problem, "Are we teaching our students to reason?" with the result of improved methods and a consequently greater utilization of this important function.

VESTIBULAR SENSITIVITY TO INTERMITTENT PASSIVE ROTATION OF THE BODY [1]

BY

ROLAND C. TRAVIS

INTRODUCTION

It is generally known that the adequate stimulus for the excitation of the ampullae of the semicircular canals is some change in the angular velocity of the head. Intermittent passive rotation as well as passive rotary oscillation of the body, in the form of harmonic motion, presented regularly recurrent stimuli which proved peculiarly favorable for a study of the sensitivity of the semicircular canals and consequent voluntary response.

A previous invesigation (1) of vestibular sensitivity to rotary oscillation showed certain relationships between the intensity and frequency of stimulation and voluntary, manual response. Within the limits of these experiments, with the interval between stimuli constant, the percentage of right responses varied directly with the average acceleration. The results as to the relation between frequency of stimulation and correct response, with the average acceleration of the canals constant, were inconclusive for rotary oscillation. It was made clear in this report that the concept of the threshold could not be satisfactorily applied to the data, except as a convenient central measure; and that distributions and curves of relationships seemed to be the only way of giving adequate expression to positive and negative reactions.

The amplitude and frequency of oscillation were systematically varied in producing subliminal and supraliminal stimulation, but the *duration* of each stimulus and the *interval* between recurring

[1] This study was made during tenure as a National Research Fellow in the Biological Sciences. Acknowledgment is due to Professor Raymond Dodge for his invaluable suggestions and criticisms, and to the Institute of Psychology, Yale University, for its cordial hospitality and facilities which made this research possible.

stimuli could not be varied independently. The intention of the investigation described in this paper was to control the duration of each stimulus independently of the interval between recurring stimuli, at constant average accelerations of the semicircular canals; also to determine the relationships between rapidity of stimulation, average acceleration, and correct response. In order to carry out this plan, intermittent rotary movements of the platform were required as the stimuli. Electric keys were pressed in response to the apparent direction and extent of rotary motion.

Methods and Technique

To vary the interval between recurring stimuli, the acceleration, and duration of each independently, required a special arrangement of the driving mechanism. In the place of the driving rod as in the previous experiments, two pawls (Fig. 1, *a, a'*) were attached 180° apart, with identical radii, to the driving wheel *b* in such a manner that when it rotated each pawl was in contact with the base *c* of the rotating platform during each half revolution of the driving wheel. This arrangement, when in operation, pro-

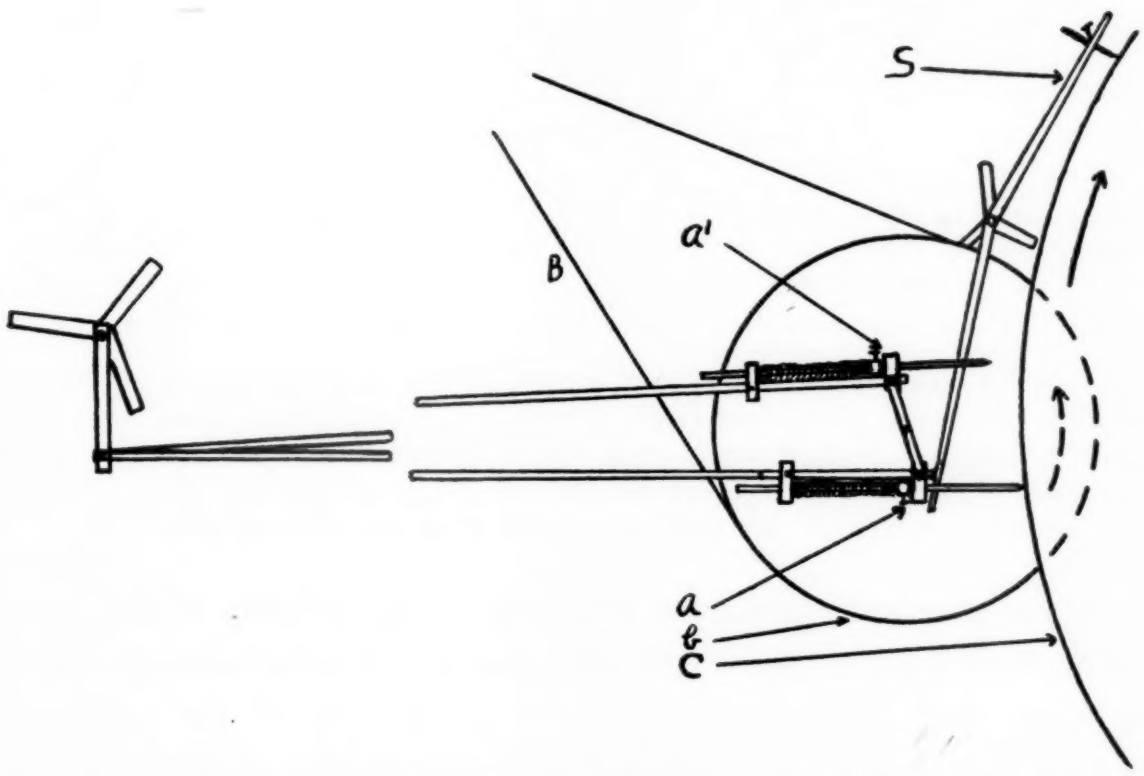

FIG. 1. Schematic diagram of the driving mechanism for producing intermittent rotary movements of the platform. *a, a'*—driving pawls; *b*—driving wheel; *c*—base of rotation platform; *B*—belt; and *S*—automatic stop.

duced a succession of rotary movements of the platform in one direction, closely following one another, when the driving wheel runs at a constant speed. A record curve of each movement of the platform approximated one-half of a sine-wave curve, as shown in Fig. 2, A. For a detailed description of harmonic motion as a stimulus mode, the reader is referred to the previous investigation. (1)

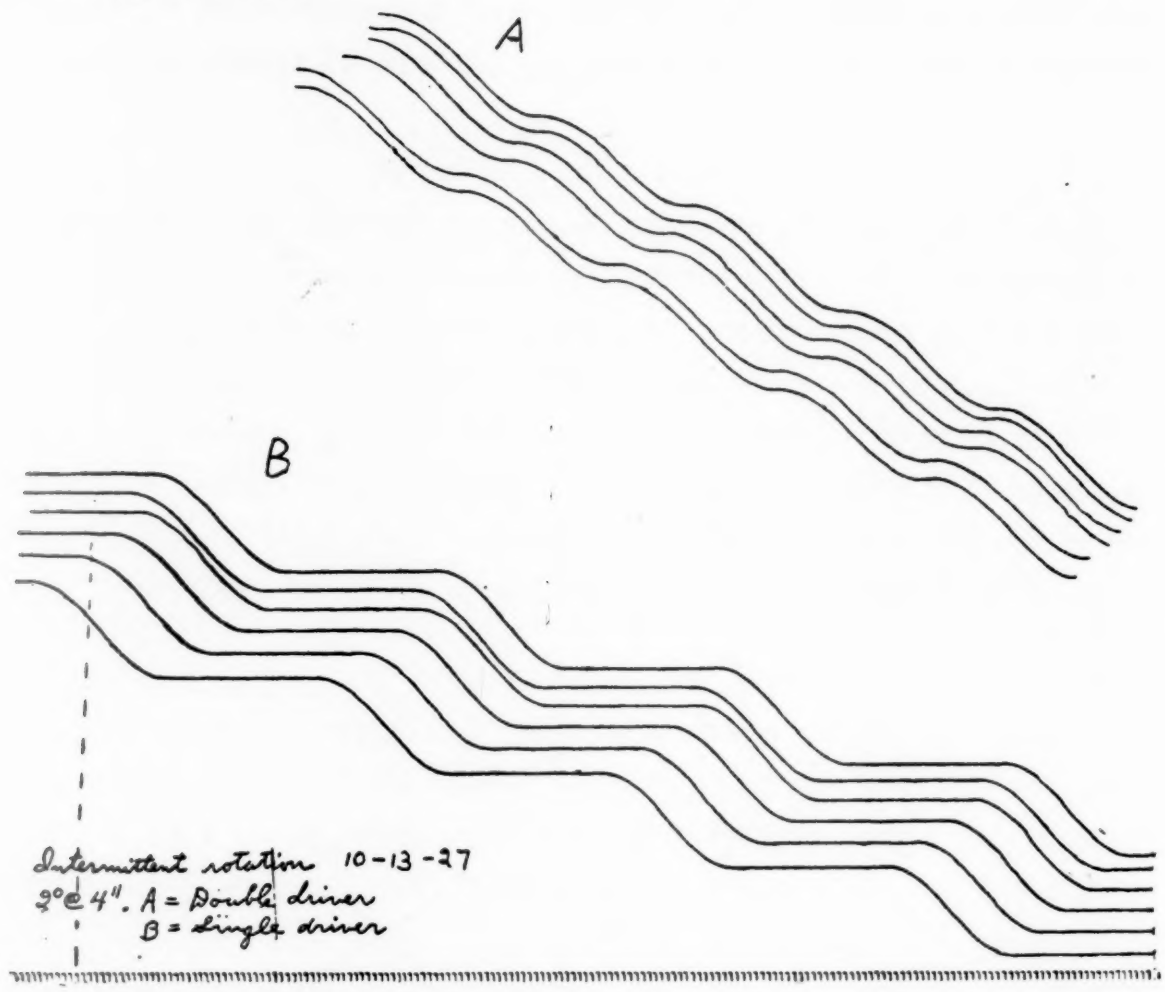

FIG. 2. *A*, a series of six record curves of the movements of the rotation platform when driven by two pawls attached to the driving wheel 180° apart with equal radii. Each wave in each record corresponds to 2° rotation of the platform. *B*, a series of six record curves of the movements of the rotation platform when driven by one pawl only, with alternate still-periods.

When only one pawl was attached to the driving wheel, alternating rotary movements and still periods of approximately equal duration were produced. A sharp projection of the automatic stop shown in Fig. 1 made contact coincidently with the release of each pawl from the base of the platform, and conversely was automatically released coincidently with the contact of each pawl

with the base of the platform. This arrangement prevented backlash of the platform, because either a pawl or the " stop " was in contact with its base. A record of the platform driven with one pawl is shown in Fig. 2, *B*. As is obvious, whether one or two pawls operate the curves are identical, but the interval between curves is longer when the platform is driven by one pawl than when driven by two. Thus the interval between recurring movements, or frequency, and the duration of each can be varied independently.

Two pawls attached to the driving wheel 180° apart, with unequal radii, so that one pawl moves the platform 3° and the other 1°, produce alternate smaller and greater angular movements in succession (see Fig. 3 for the record).

The subject responded to the perception of motion by pressing

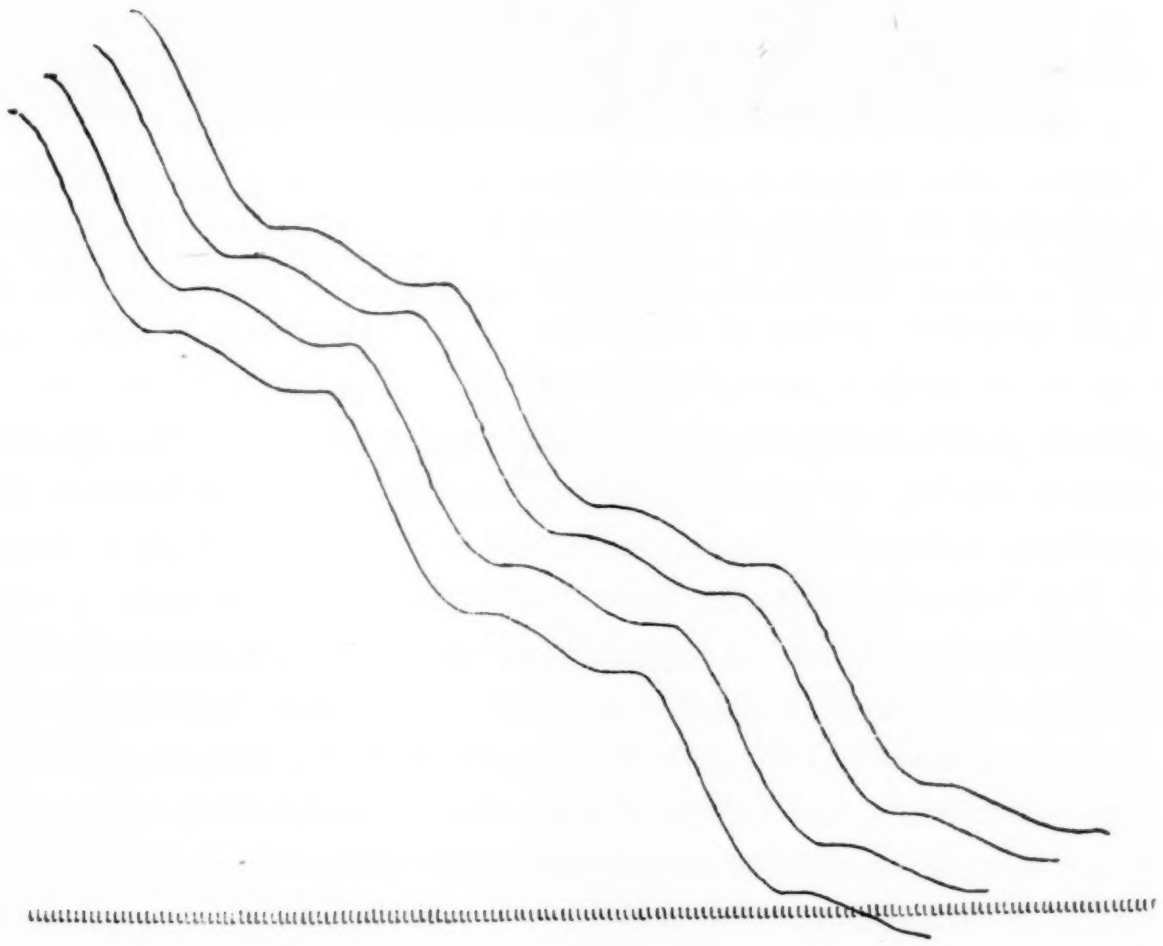

FIG. 3. A series of four record curves of the movements of the rotation platform when driven by two pawls attached to the driving wheel 180° apart with unequal radii. The pawl with the shorter radius rotated the platform 1°; while the pawl with the longer radius rotated the platform 3° at each rotation of the driving wheel.

appropriate electric keys which activated the pointer of a Dodge duplex marker. If the subject perceived motion to the right he responded by pressing the right-hand key; if he perceived motion to the left he responded by pressing the left-hand key (see the two records in Fig. 4). The pointer of the duplex marker moved in one direction when the right-hand key was pressed (downward movements of top line of each record in Fig. 4) and in the opposite direction when the left-hand key was pressed (upward movements of top line of each record in Fig. 4). Electrical contacts

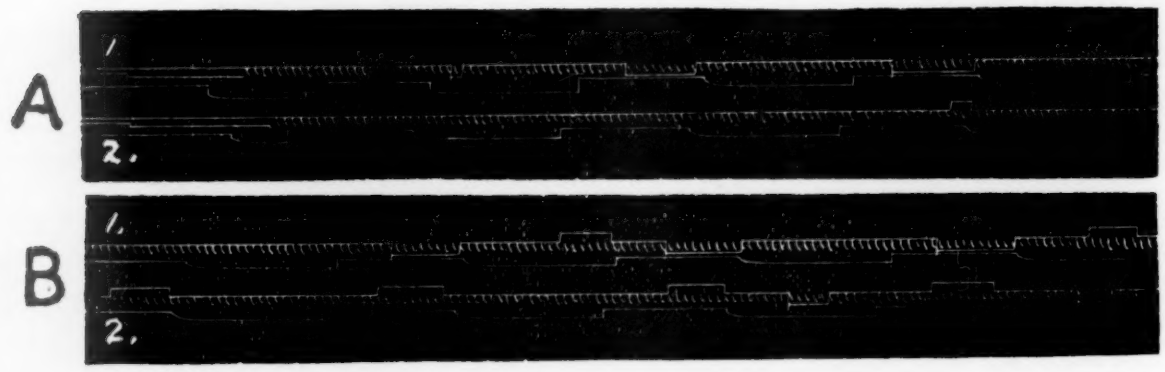

FIG. 4. Two records (1 and 2) indicating the beginning and end of each movement of the platform (bottom line in each record), and the direction and extent of the perception of motion (top line in each record). Time line is in tenths of second. Records should be read from left to right and sections A and B are consecutive portions of one record.

on one pawl made a circuit which actuated the pointer of another electric marker at each release of the pawl from the base of the platform (downward movements of bottom line of each record in Fig. 4). Conversely, the circuit was broken at each contact of the pawl with the base of the platform (upward movements of bottom line of each record in Fig. 4). Thus records of the beginning and end of each movement of the platform, the incidence, direction, and extent of the subject's perception of motion, and a time line in tenths of a second were obtained.

The subject's eyes were covered to eliminate vision. A constant noise produced by an electric fan striking on paper masked any auditory cues of motion. A headrest always held the subject's head in position. Two periods of no physical movement were included in each series to insure finer discrimination.

The displacements, frequencies, durations, and average accelerations of the canals for one and two pawls used in intermittent rotation are given in Table I.

TABLE I. *Different factors in the arrangement of the stimuli*

Angular Displacement. Degrees	Frequency. Interval between similar phases—Seconds. One pawl	Two pawls	Duration of each stimulus. Seconds	Ave. accel. Cm. per. sec.
1	1.4	0.7	0.7	.02
4	8	4	4	.02
2	4	2	2	.02
1	4	2	2	.0024
4	4	2	2	.072
3 for one pawl	3	1.5	1.5	.116
1 for other pawl	3	1.5	1.5	.0043

The first three displacement-frequency combinations give equal average accelerations at varying frequencies and durations, while the next three give equal frequencies and durations at varying average accelerations for each pawl. This arrangement of stimuli permitted the determination of the relations between either variant and the percentage of correct responses with the other variant constant. The last two displacement-frequency combinations afforded a means of analyzing the reciprocal effects of less intense and more intense stimuli.

Two trained subjects (Mr. Herbert Gurnee, instructor in psychology, and the writer) participated regularly in these experiments and are designated as HG and RCT.

Average Acceleration and Correct Response

The relationship between the average acceleration and the percentage of right responses with frequency and duration constant, as shown in Fig. 5, is analogous to the systematic relationship between acceleration and response given in the previous investigation (1) of passive oscillation. Again in these experiments there is an almost rectilinear relationship between stimuli ranging from far below to above the 50 per cent threshold and voluntary manual response. Such a relationship in intermittent rotation might be expected in view of the similarity of the two stimulation conditions. On the other hand, the fact that rotary oscillation pro-

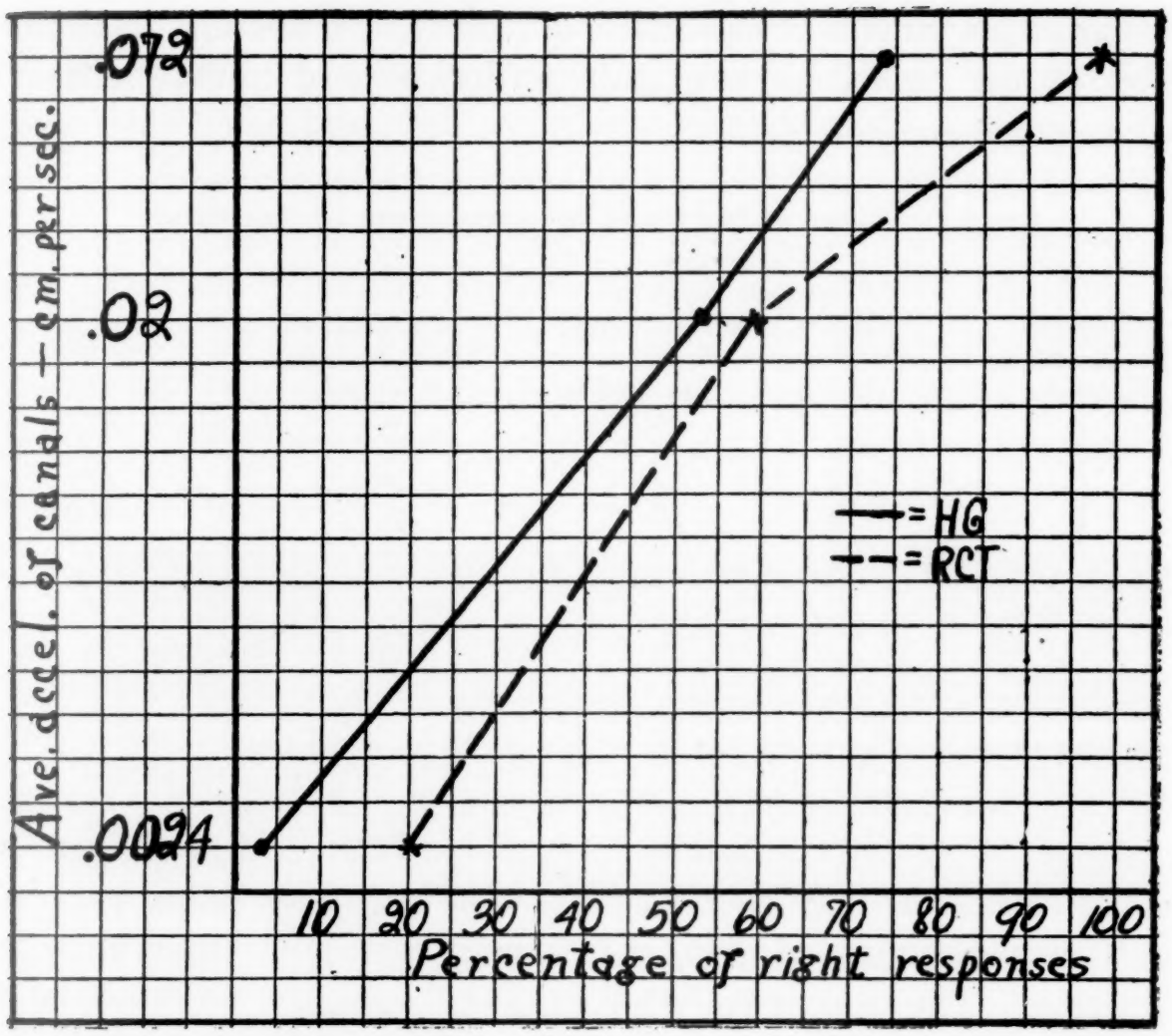

FIG. 5. Relationship between the average acceleration of the canals and the percentage of right responses with the interval between stimuli and the duration of each constant at 4″ for one driving pawl.

duces alternate stimulation of the right and left vestibular systems, while intermittent rotation produces stimulation either of the right or left system, might lead one to suppose that differences would result in regard to such factors as thresholds, sensory rivalry, adaptation, and relative refractoriness in comparing the two stimulation conditions. The thresholds are apparently about the same for the two different modes of harmonic motion.

The 50 per cent threshold of one subject (RCT) in average acceleration of the semicircular canals is .0108 cm. per second for *rotary oscillation* and .0124 cm. per second for *intermittent rotation.* This threshold difference between the two stimulation conditions is too slight to be significant. The 50 per cent threshold of HG is .041 cm. per second for intermittent rotation, which is

slightly lower than that (.0444) of subject (RD) for rotary oscillation in the previous investigation. The thresholds in intermittent rotation represent the averages of the stimuli to the right and to the left, that evoke 50 per cent right responses.

Comparison of vestibular sensitivity to rotation to the right and left showed that the sensitivity to rotation to the right was 19 per cent greater for HG and 22 per cent greater for RCT than sensitivity to rotation to the left. Whether this difference is due to the relative effectiveness of the right and left stimuli or to the relative sensitivity of the right and left vestibular receptor systems cannot be answered directly from the experimental data. The headrests were permanently set as accurately as possible so that the axis of rotation would run midway between the two

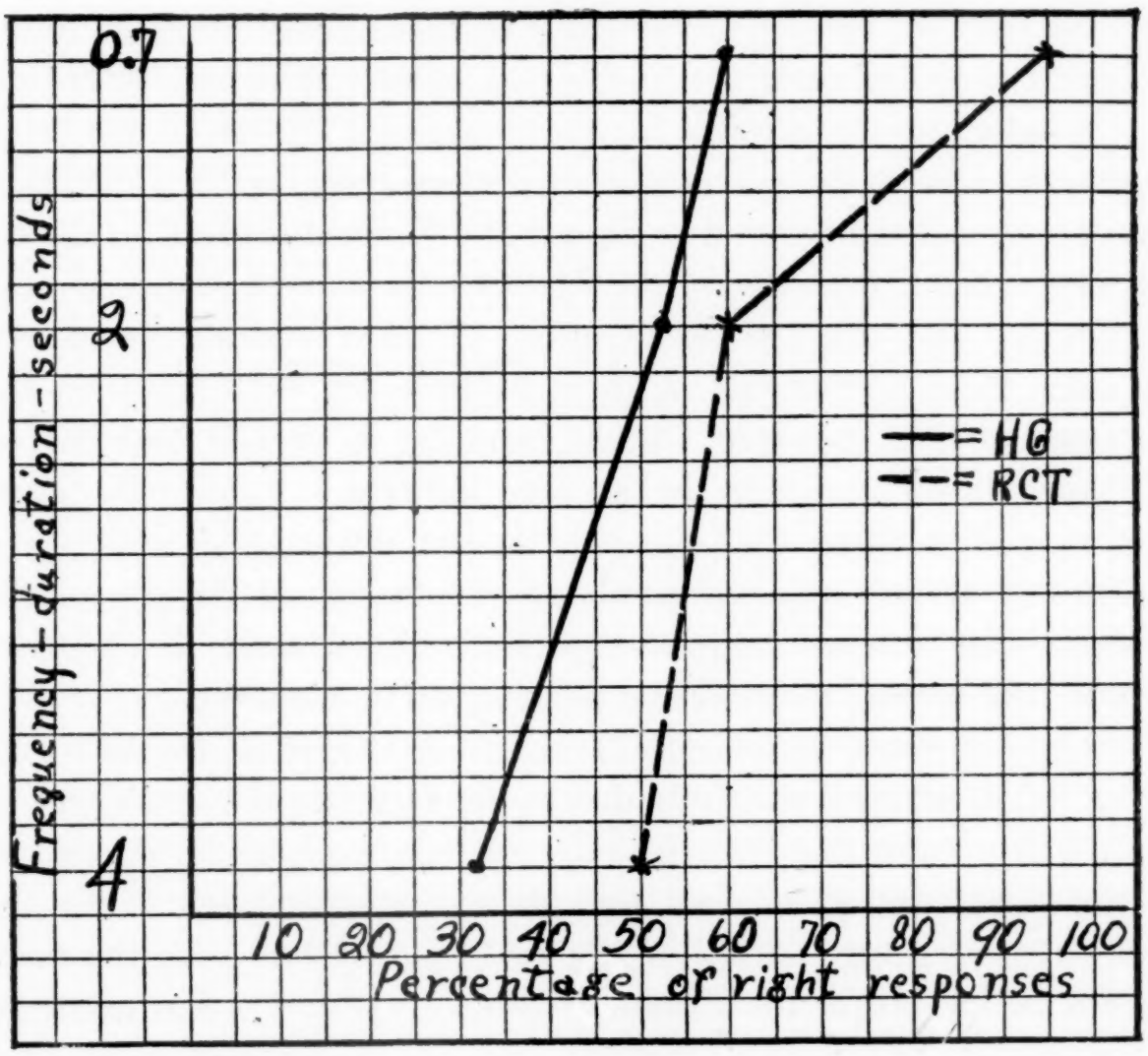

FIG. 6. Relationship between frequency-duration and the percentage of right responses with the average acceleration of the canals constant at .02 cm. per second.

labyrinths. At the best, however, this was only an approximation. Thus the difference found might hypothetically be due to a slight eccentric position of the right and left canal systems permitting a more intense stimulus of one side than of the other. On the contrary, in view of the previous data on vestibular sensitivity with the canals at various gross distances from the axis, it seems reasonable to believe that such a minute relative difference as might have occurred in the distances of the two horizontal canals from the axis would be insignificant.

Relationship Between Frequency-Duration and Correct Response

The relationship between frequency-duration and the percentage of right responses with the average acceleration of the canals constant at .02 cm. per second, as shown in Fig. 6, indicates that as the interval between recurring stimuli decreases and the duration of each decreases the number of correct responses increases.

What effect the interval between recurring stimuli of the same duration has on the percentage of correct responses is a different question. It is answered in Figs. 7 and 8, which show the relation between the frequency of stimulation and correct response with duration and average acceleration of each stimulus constant. Under these circumstances, in every case for both subjects, the longer interval between stimuli produces a greater number of correct responses than the shorter interval. Apparently these relationships show that the shorter the duration of each of a series of stimuli of equal acceleration intensity of the canals, the longer the interval (within certain limits) must be between recurring stimuli to evoke the most adequate response.

The difference between the frequencies is greater for HG than for RCT, which is probably due to the fact that the sensitivity of RCT is greater than that of HG. It seems probable, if one can generalize from these data, that these frequencies fell within the relative refractory period of the vestibular system with the rapid ones falling nearer the absolute refractory period. Furthermore, the number of negative reactions averages 20 per cent greater for the greater of any two frequencies compared in Fig. 7 for HG and 17 per cent greater in Fig. 8 for RCT. This probably means

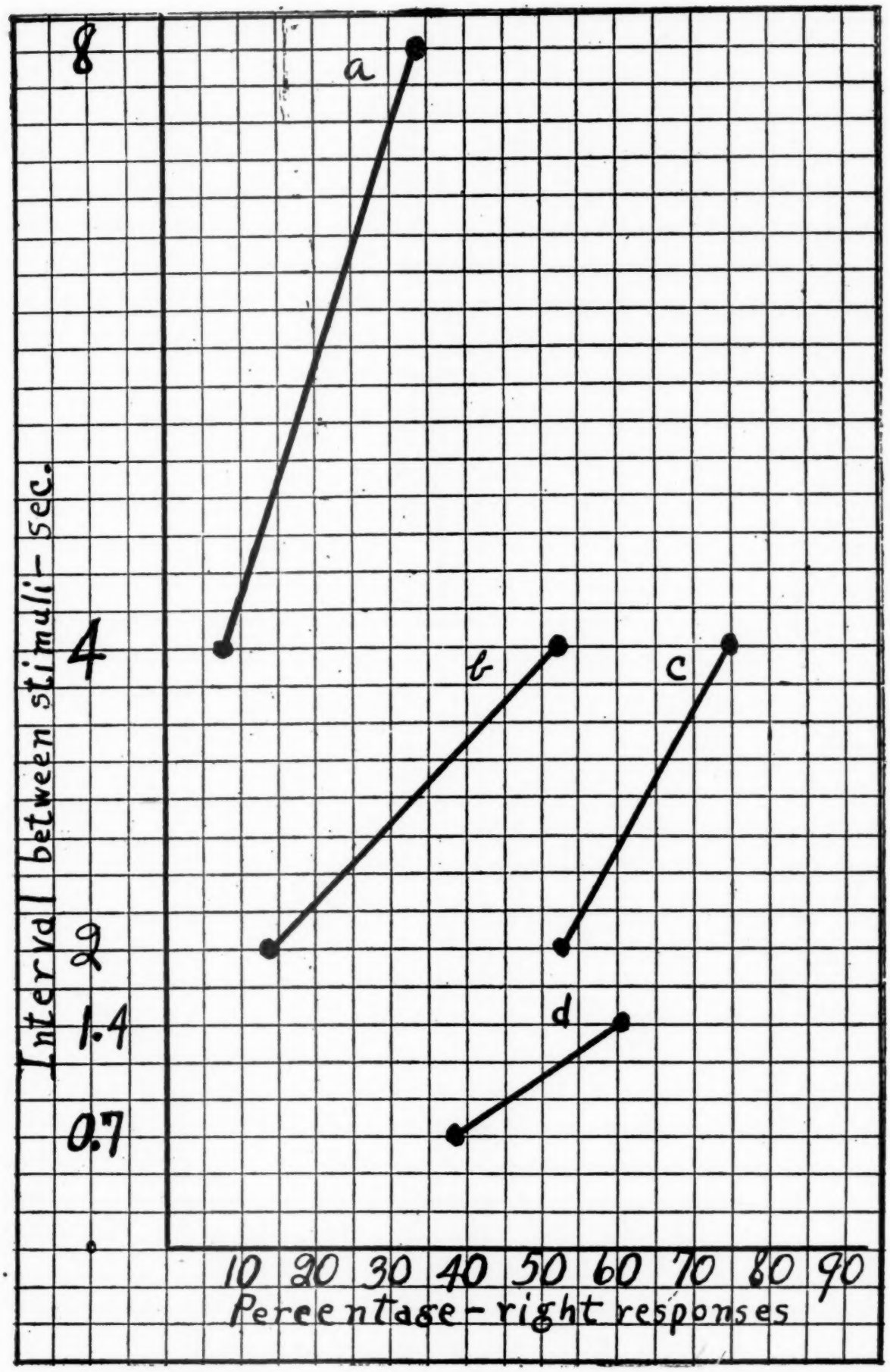

FIG. 7. HG. Relationship between frequency of stimulation and the percentage of right responses with the duration and average acceleration of each of the four pairs of stimuli constant. *a*—duration of each recurring stimulus of 4″, average acceleration of canals of .02 cm. per sec. *b*—duration of 2″, average acceleration of .02 cm. per sec. *c*—duration of 2″, average acceleration of .072 cm. per sec. *d*—duration of 0.7″, average acceleration of .02 cm. per second.

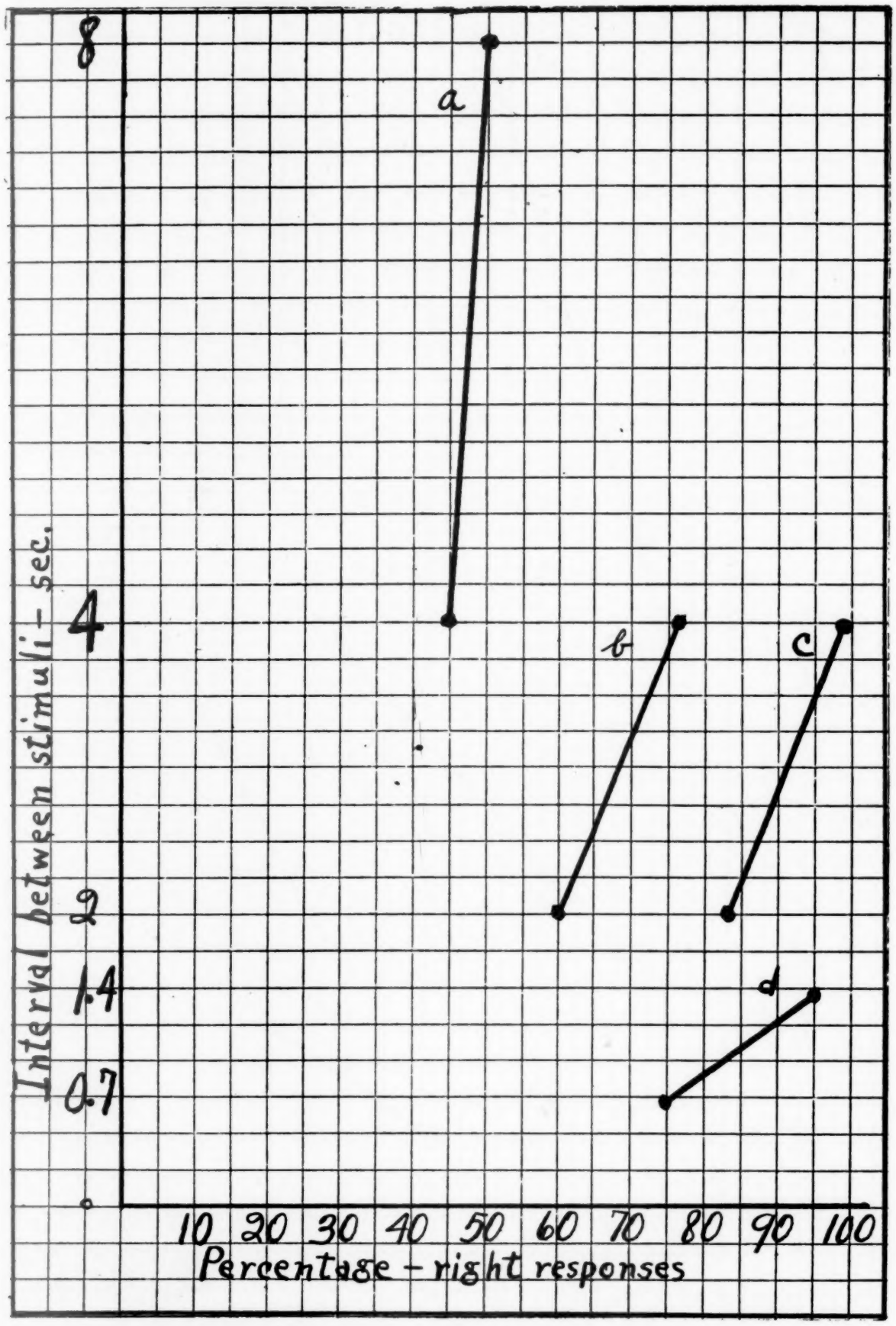

FIG. 8. RCT. Same arrangement as in Fig. 7.

that as the interval between recurring stimuli approaches the absolute refractory period the percentage of negative reactions, or the

perception of motion in the wrong direction, becomes progressively greater. This is also true for the number of zero reactions.

Explanation of the increase in negative reactions is not clear. In some unknown way relative refractoriness seems to be connected with negative reactions which occur more regularly to subliminal intensities in passive *rotary oscillation,* notwithstanding the fact that rather slow frequencies were used. This is congruent with the fact that the lower the intensity of a stimulus the longer the refractory period of the system which reacts to it.

Reciprocal Effects of Less and More Intense Stimuli

When the two pawls are attached to the driving wheel 180° apart with unequal radii, so that one moves the platform 3° and the other 1° in each rotation of the driving wheel, alternating recurrent smaller and greater angular movements of the platform are produced. When the 1° pawl was removed, alternating 3° movements and still-periods of approximately equal duration were produced. Likewise, when the 3° pawl was removed, alternating 1° movements and still-periods of approximately equal duration were produced. This arrangement of the driving mechanism afforded a means of analyzing the reciprocal effects of less and more intense stimuli. Table II gives the average per-

TABLE II. *The average percentages of the right responses*

Subject	Alternating 3° in 3″–1° in 3″		Alone 3° in 3″	Alone 1° in 3″
HG	51	0	53	10
RCT	76	0	71	18

centage of right responses for six trials of fifty successive stimuli each for the alternating less and more intense stimuli, for the more intense stimuli alone, and for the less intense stimuli alone.

It seems clear from this table that the less intense has little or no significant effect on the more intense stimuli, while the more intense completely inhibits the less intense stimuli. The effects of strong stimuli on later weaker ones may prove to be a case under Heymans' law (2) of the inhibition of less intense by more intense stimuli. On the contrary, the writer is not certain whether the fainter stimulus did not in each repetition fall within

the refractory period of the stronger. The evidence for a relative refractoriness of the vestibular system to rotary movements supports the latter interpretation.

Summary of Results

As a step further in the experimental analysis of vestibular sensitivity to appropriate changes in the angular velocity of the head and consequent voluntary response, the following conclusions bear directly only on the results from stimulation of the semicircular canals by intermittent passive rotation.

1. The percentage of right responses varies directly with the average acceleration of the canals when the interval between recurring stimuli and duration of each are constant.

2. The 50 per cent thresholds of one subject (RCT) in average acceleration of the canals are closely similar for rotary oscillation (.0108 cm. per sec.) and intermittent rotation (.0124 cm. per sec.). The 50 per cent threshold of subject (HG) for intermittent rotation (.041 cm. per sec.) and that of subject (RD) for rotary oscillation (.0444 cm. per sec.) are closely similar.

3. Vestibular sensitivity to rotation to the right was 19 per cent greater for HG and 22 per cent greater for RCT than that to the left. This difference may be due to the relative sensitivity of the right and left vestibular receptor systems.

4. The percentage of right responses varies inversely as the interval between recurring stimuli and duration of each, when the average acceleration of the canals is constant.

5. The percentage of right responses varies directly as the interval between recurring stimuli of the same duration with the average acceleration of each constant.

6. It may be inferred from (4) and (5) that as the interval between recurring stimuli becomes longer and as the duration of each (within limits) becomes shorter with the average acceleration constant, the voluntary response becomes more adequate.

7. As the interval between recurring stimuli approaches the absolute refractory period of the vestibular system, the less adequate the response becomes, and the number of negative reactions becomes greater.

8. A more intense stimulus completely inhibits a later less intense stimulus of the vestibular system, while the less intense has no significant effect on the more intense. This phenomenon may be an extension of Heymans' law to successive stimuli or it may be attributable to the effects of refractoriness. Possibly these are really different aspects of the same fundamental neural process.

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IOWA PLACEMENT EXAMINATIONS—A NEW DEPARTURE IN MENTAL MEASUREMENT

BY

GEORGE D. STODDARD

The Iowa Placement Examinations are perhaps the first tangible fruits of a new theoretical approach to the problem of mental measurement, in so far as the college field is concerned. For some time it has been common knowledge among technical workers that the ordinary intelligence test, when applied beyond the age of sixteen, was much more open to criticism than at lower levels; the tests available were ill adapted for measuring the superior people and the necessary assumption regarding equality of opportunity and effort was somewhat strained. Moreover, it was becoming increasingly apparent that the workers responsible for the measurement of college students were not primarily interested in measuring native mental ability free from the effects of environment; they were engrossed in the problem of prediction of success in college. Only a few general mental tests in the older tradition have been found useful in prognosis of college success. The recent Scholastic Aptitude Test of the College Entrance Examination Board constitutes a selection of the army type sub-tests which may be expected to yield the maximum results obtainable with such tests. Its title is significant, and its authors point out explicitly that it may or may not measure "general intelligence," but that "there is a tendency for individual differences in scores in these tests to be associated positively with individual differences in subsequent academic attainment." It is the opinion of the present writer that this test marks the end-point of development of the general psychological examination for college entrants: the time has come for new theories and new methods.

Since the prediction of academic success is the avowed aim of college entrance examinations, why not develop a technic devoted

specifically to that end? Moreover, since each college department is also primarily concerned with the success of students in the subjects it represents, why not estimate the probability of success of the Freshmen in each of their major subjects? Finally, why not combine both objectives in a single battery of tests, since general academic success is, after all, only a composite of grades received in specific subjects?

These questions led to further principles which were formulated by Dean C. E. Seashore, viz. (9):

"1. It is devoted to specific subjects or fields of knowledge, such as English, mathematics, or chemistry.

"2. It differentiates between training in a subject and natural aptitude or fitness for that field of work.

"3. It is a departmental affair and is given separately by each department in its immediate interests and needs.

"4. It serves as an introduction to the subject, being prepared with the purpose of reminding the student of the essential prerequisites for the course and indicating the general character of the activity that will be pursued in the course, and being so written from the point of view of the art of teaching that it shall constitute the most profitable exercise for the first two hours of the course.

"5. This examination should give, at the end of two hours, as adequate information about the student's place and needs in the course as the instructor ordinarily acquires by the end of the first semester under the traditional method of instruction.

"6. The record of a general intelligence test may be used to supplement this examination, but that is not essential, as a series of placement aptitude tests will be more significant than a general intelligence test.

"7. It is prepared by, or in responsible collaboration with, a successful teacher and writer in the specific subject.

"8. It is given for a specific purpose, and the results may be applied immediately in the organization of sections of the class on the basis of this objective information about the character of the preparation and the natural aptitude for the subject."

These principles comprised an adequate working program, and

the writer carried on the investigation under the direction of C. E. Seashore and G. M. Ruch, and with the collaboration of the University of Iowa and the Society for the Promotion of Engineering Education. As the work progressed certain judgments appeared as corollaries to those cited above. Thus (11) "it is better to infer aptitude for a particular subject through a test which combines those mental skills that are discovered to play a part in the subject than from a test which gives a more general measure of mental ability; a number of placement examinations lead to a profile of one's mental-educational skills, which in the case of adults is more intelligible and more significant than a single measure such as I.Q.; prediction of both general academic success and performance in specific subjects is more accurate with Placement Examinations than with general psychological tests."

As there is not space here to give an adequate picture of the examinations themselves, a suggestive bibliography is included at the end of this paper. The examinations cover the following subjects: English, mathematics, chemistry, physics, French and Spanish, each being represented by two series (with two forms for each test): an Aptitude Examination which measures those particular mental abilities which are related to subsequent success in the subject, and a Training Examination which is primarily a standardized achievement test of sufficient scope and difficulty to be used at the college level. The Aptitude Examinations are closest to the usual mental ability test, but they do not hesitate to draw on learned material which is an essential preliminary to the work at hand. Thus an arithmetic section is found in the Chemistry Aptitude Examination, while reading ability is measured throughout the series. Two examinations, Mathematics Aptitude and Foreign Language Aptitude, will suffice to illustrate the concept of "aptitude for a subject" which has been incorporated in the Iowa tests. The first consists of measures of the ability to complete arithmetic and algebraic number series, to solve original problems involving spatial imagination, to succeed with symbolic logic, and to comprehend new and difficult mathematical reading material; the second measures knowledge of English parts of speech, inflections, and roots, transfer of training from English

to an unfamiliar language (Esperanto), skill in grammar principles, comprehension, and translation in a strange language (Esperanto).

The Training Examinations were validated in the usual manner, and serve as reliable, objective measures of high school performance in the subject. In the aggregate they constitute a much better estimate of the secondary school work of the students in the field tested than is given by school marks.

It is clear that the Iowa Placement Examinations involve a duplex system of measurement which covers the junction of secondary and higher education. Since they have been increasingly in demand on the part of colleges and universities, it is possible to recapitulate briefly at this time the actual uses which have been made of the test results:

(1) To afford a basis for prediction of the character of the work that each student will do in college.

(2) To aid in selecting and admitting students.

(3) To serve as a content entrance examination (the training series).

(4) To section classes for instructional purposes.

(5) To assist in deciding how much work a student can carry.

(6) To deal more effectively with students who are not well oriented in their college work; *e.g.,* students who fail their work but possess adequate mental ability; students who work hard but do not succeed; students on probation for various delinquences, etc.

(7) To give aid in vocational guidance.

(8) To furnish a basis for the diagnosis of individual and class weaknesses.

(9) To enable high schools and preparatory schools to survey their seniors or graduates in order to determine probable fitness for college studies.

A few universities, indeed, have utilized the examinations for practically every one of the purposes listed; others only in a departmental way, or to meet the needs of personnel directors. Private institutions are in a position to deny entrance to demonstrably deficient candidates, while state universities simply advise

and recommend, or adopt a policy of careful surveillance in regard to bad risks among incoming students.

In view of the extensiveness and importance of these applications it may well be asked, What results have been obtained? Unfortunately some of the most important findings with respect to student personnel procedures are very discursive (involving as they do case histories) and cannot be even summarized here. For results of this nature the reader is referred particularly to the exhaustive work of Remmers at Purdue (7) and Lemon at Iowa. (6) But the usual reply to such a question is a barrage of correlations, and a sample of these compiled from many colleges during two years is given in Table I.

TABLE I. *Correlations between Iowa placement examination scores and corresponding first-semester college grades in a specific subject. (Approximate central tendencies)*

Subject	1 Series (40 minutes)	2 Series (80 minutes)
Chemistry	.50	.60
English	.55	.60
French	.60	.65
Mathematics	.55	.60
Physics	.50	.55

Since it has been implied that a combination of Placement Examinations would be suitable for predicting general academic success, particularly for the first semester, a few figures will be quoted in this connection. The most complete composite reported to date is that of Case School of Applied Science, which gave seven Placement Examinations (there are eleven in all) to 182 beginning students. The correlation between the unweighted average of the examinations and pooled grades was .75. Almost as high a figure could have been reached with a smaller composite, had that been the only purpose of the project. In fact, one test, English Training, will predict general success in the Liberal Arts College for the first semester as accurately as will most intelligence tests, while a three-hour program (four placement tests) will consistently yield a prediction of .60; this, of course, in addition to the prognosis of success in the separate subjects. The subsequent combination of scores is merely a matter of paper work

carried on at a central office. Additional correlations will be found in the studies of Langlie,(5) Symonds,(15) and Stoddard.(11) Langlie found that the Mathematics Training test predicted pooled grades in the Engineering College at the University of Minnesota to the extent of r = .61 (1925) and r = .68 (1926).

Such coefficients, by whatever means obtained, leave much to be desired: they are not a great improvement over guessing (if we are concerned about the exact rank of the students); and they are difficult to articulate with practical problems in college instruction and administration. But one of the main problems is the discovery of the weakest students who are very likely to fail, and another is the discovery and motivation of the gifted. After all, most colleges are pretty well organized to provide for the needs of the mediocre middle group. Tables II, III, and IV are inserted to indicate in a non-correlational way the prognostic power of the Iowa Placement Examinations.

TABLE II. *Iowa placement examinations, chemistry aptitude and training, Form A. Per cent of students per decile and quartile receiving grades A or B, C or D, and F (failure) at end of first semester*

	Chemistry Aptitude			Chemistry Training		
Decile	Grade A, B	Grade C, D	Grade F	Grade A, B	Grade C, D	Grade F
10	68	31	1	70	30	
9	44	51	5	51	47	2
8	34	57	9	42	54	4
7	27	64	9	30	63	7
6	26	60	14	30	60	10
5	18	67	15	22	59	19
4	18	63	19	31	58	11
3	12	63	25	26	66	8
2	5	65	30	19	61	20
1	3	51	46	8	62	30
Upper quartile	51	45	4	58	41	1
Upper middle quartile	28	61	11	32	60	8
Lower middle quartile	18	64	18	27	60	13
Lower quartile	6	60	34	16	61	23
	Number of cases = 3015			Number of cases = 634		

These tables are probably self-explanatory. Thus, considering those students who stood in the upper tenth in Chemistry Aptitude, it is found that 68 per cent received A or B for the work of

the course, 31 per cent received C or D, and 1 per cent failed to pass. But of those who stood in the lowest tenth only 3 per cent earned an A or B at the end of the semester, while 51 per cent received C or D, and 46 per cent failed. Successive deciles are not sharply distinguished, but there is no question about the distinction between adjacent quartiles. All values, it should be borne in mind, were obtained on the basis of fully prepared college Freshmen; yet the chance (or index) of success for some individuals was forty times that of others. Hence it is apparent that relationships represented only by moderately high coefficients of correlation (.50 to .60) may, when analyzed in this fashion, prove of both theoretical and practical significance.

Certain critical objections which have been raised against the Iowa Placement Examinations may be touched upon at this point. Langlie, in his first study of the tests,(3) reports among other conclusions:

"(1) Each test is dependent to a fair degree upon intelligence, particularly the aptitude tests.

TABLE III. *Iowa placement examinations, English aptitude and training, Form A. Per cent of students per decile and quartile receiving grades A or B, C or D, and F (failure) at end of first semester*

	English Aptitude			English Training		
Decile	Grade A, B	Grade C, D	Grade F	Grade A, B	Grade C, D	Grade F
10	61	37	2	69	31	
9	44	50	6	58	40	2
8	34	61	5	50	47	3
7	35	56	9	40	57	3
6	36	57	7	28	62	10
5	21	71	8	15	79	6
4	18	72	10	19	72	9
3	16	67	17	25	67	8
2	11	77	12	9	81	10
1	5	73	22	3	80	17
Upper quartile	49	46	5	57	41	2
Upper middle quartile	35	58	7	40	55	5
Lower middle quartile	20	71	9	18	74	8
Lower quartile	8	74	18	11	78	11
Number of cases =	2744			2900		

TABLE IV. *Iowa placement examinations, mathematics aptitude and training, Form A. Per cent of students per decile and quartile receiving grades A or B, C or D, and F (failure) at end of first semester*

	Mathematics Aptitude			Mathematics Training		
Decile	Grade A, B	Grade C, D	Grade F	Grade A, B	Grade C, D	Grade F
10	55	39	6	50	43	7
9	48	41	11	36	56	8
8	38	55	7	30	55	15
7	25	58	17	28	58	14
6	22	63	15	15	63	22
5	19	59	22	25	58	17
4	22	59	19	9	60	31
3	9	60	31	7	58	35
2	12	57	31	5	50	45
1	7	42	51		39	61
Upper quartile	50	42	8	42	50	8
Upper middle quartile	26	60	14	22	59	19
Lower middle quartile	18	59	23	15	60	25
Lower quartile	9	54	37	3	45	52
	Number of cases = 1931			Number of cases = 1093		

"(2) A particular aptitude is dependent upon training in that particular line.

"(3) Aptitude (is) general intelligence plus training."

Intelligence was measured by the Minnesota Intelligence Test and the Iowa Placement Examinations used were in English, mathematics, and chemistry. The first statement simply points out that intelligence as measured by tests has something in common with aptitude for performance in a school subject, and with performance in that subject. This is to be expected, especially in view of the fact that the aptitude examinations are in reality a special type of intelligence test: their chief departure from the content of the classic test being in the direction of relevancy to the subject for which the prediction is desired. Langlie's second statement is essentially fallacious, for it arises out of an accident of sampling. All students who took the aptitude tests had really studied the subject matter for which the tests were designed to measure aptitude. For example, the same students took both the Chemistry Aptitude and Chemistry Training Examinations. Since they had studied chemistry in high school, there was a correlation

between chemistry aptitude and chemistry performance. But the Chemistry Aptitude Examination is designed principally for those with no training in chemistry; when given to such students it surely becomes meaningless to say that aptitude *depends upon* training. This would follow also for physics, French, and Spanish. That Mathematics Aptitude does not depend upon Mathematics Training is evidenced by the variability of scores in the Aptitude Test, among students equal in mathematics achievement; if not by a casual examination of the contents of the test. Finally, Langlie's third statement, which cannot be true with respect to the "plus training" phrase, is not strictly accurate in the first portion, since only a composite of aptitude tests could be looked upon as embodying a general measurement, and this only with respect to academic achievement in a narrow range.

To the question, Has a real distinction been made between aptitude and training (for a particular subject)? it may be answered that the correlations between the two series are much lower than the reliabilities of the examinations, and that the aptitude tests can all be given to students thoroughly unfamiliar with the school subject.

Are the aptitude tests really specific? Each one will predict success in other subjects (sometimes reasonably well), but the test designed for a subject predicts success in that subject better than it does in others and is superior to the other aptitude tests in this respect. Analogous statements are true for the examinations in the training series.

To summarize: The Iowa Placement Examinations are the outgrowth of a distinctive theory in mental measurement at the college level; they have found wide usefulness among universities; and their subsequent development is likely to be in the nature of refinement of a technic believed to be valid in the light of preliminary evidence.

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SEASHORE'S PLAN OF SECTIONING ON THE BASIS OF ABILITY AS A MOTIVATION DEVICE

BY

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The ingenious plan of sectioning large classes in grade schools, high schools, colleges, and universities on the basis of ability has, during the past half decade, come to be recognized by administrators and teachers as a plan of outstanding merit. That it is the most successful method of dealing effectively with the various abilities found in any large class of students is no longer questioned.

This is evidenced by the fact that during the past few years the National Research Council, the Association of University Professors, the Association of Land Grant Colleges, the Board of Investigation of Engineering Education, and their affiliated agencies have strongly advocated the general use of this plan. Further evidence of the extended use of the sectioning plan is contained in Dean Seashore's article, "Sectioning on the Basis of Ability," which appeared in the February-March, 1926, Bulletin of the American Association of University Professors. On the basis of a survey made in 1924–25, the author estimates that fully half of the leading colleges and universities are using the plan in one or more departments.

The chief merit of this plan lies in the fact that it takes into account the fundamental psychological differences between students and provides an effective way of dealing with such differences. In the language of Professor Seashore, the plan makes it possible "to apply in teaching the pedagogical maxim, which is the outcome of the discovery of the individual, namely, 'Keep each student at his highest level of achievement in order that he may be successful, happy and good.'"

It is not within the scope of this paper to point out all the merits

of or to review the objections to the sectioning-on-the-basis-of-ability plan. Several excellent bulletins setting forth the system in considerable detail are available for the asking.[1]

It is rather the aim of this paper to point out the value of the sectioning plan as a motivation device, as revealed by some specific studies made in connection with certain of the "low" sections in elementary psychology at the State University of Iowa in 1924.[2]

Motivation, as applied in the field of education, implies any means of spurring students on to greater interest and achievement in the tasks and disciplines set by the school. The sectioning plan is preëminently one of motivation, because (1) it appeals to the fundamental instinctive mechanisms of rivalry and emulation, (2) it appeals to the student's pride and self-respect, (3) it is based on reasonable standards of achievement, (4) it is based on the principle of adequate reward and punishment, and (5) it is constant in its influence and appeal.

Space will not permit even a brief discussion of these five criteria of motivation, however they may be summed up admirably in the statement of Professor Seashore himself. "The introduction of fair standards of achievement creates student morale. The capable student who has been loafing on the job is one who is most likely to be affected by this method. Each man, be he high, average or low, is made to feel responsible for himself, feel his opportunity, feel the stimulus for competition, feel the joy of achievement, feel the approval of a clear conscience, feel busy, feel the joy of approbation if deserved."

The plan admirably rewards those who seek to achieve and punishes those who are content to shirk. In the results reported below it will be noted that there are several students who began in a "low" section and ended the school year in the highest

[1] Seashore, C. E., Sectioning on the basis of ability, *Bull. Amer. Assoc. Univ. Professors,* 1923, IX, 9–24; Sectioning classes on the basis of ability, *School & Soc.,* 1922, XV, 353–358; Learning and Living in College, Iowa City, Univ. of Iowa Stud., II, No. 1 (undated).

[2] In 1923–25, the writer as a graduate assistant, served as an instructor of several conference groups of the class in Elementary Psychology, numbering approximately 800, and sectioned on the basis of ability according to Dean Seashore's plan. The results reported herewith are a portion of a more elaborate study made in connection with his M.A. thesis.

section. Likewise there are some who were demoted from high to low sections because they ceased striving, whatever may have been the reason.

For a study of the motivation value of the Seashore plan of sectioning, three typical "low" sections of the large class in elementary psychology, having a total enrollment of sixty students, were selected. The study was started at the beginning of the second semester's work. All students in the three groups had completed the first half of the course. The first shift was made on the basis of the grades earned in the first semester (within ten days after the opening of the second semester) and three other shifts were made during the remaining sixteen weeks. As a rule, the shifting was done immediately following the examination periods.

The same type of instruction in the content of the course as was employed in the other four sections, conducted during the same period by the writer, was used in the three sections selected for study, that is, all the sections under the control of the writer were conducted in the same manner.

Results

As previously mentioned, the total enrollment in the three sections was 60 students, 34 men and 26 women. During the semester a total of 25 students, 15 men and 10 women, or 42 per cent of the class, were shifted into higher sections in accordance with the rules of transfer. Furthermore, a total of 11 students, 7 men and 4 women, were eligible for promotion to higher sections at the end of the semester period. This makes a total of 36 students, or 60 per cent of the enrollment, who definitely responded to motivation.

During the same period, 15 students, 10 men and 5 women, were received into these "low" sections from other groups. Only 12 students, or 20 per cent, remained in these low sections during the entire semester. It is interesting to note that only one man was returned to the "low" section after he had been promoted at a previous transfer period.

Of the 25 students promoted during the semester, 2 men and 2

women reached high sections, while 8 men and 13 women reached the middle level.

Another important fact is that the average class standing of the three "low" sections increased from 1.56 to 1.87 during the semester period in which the observations were taken.

Tabular Summary of Results

	Men	Women	Total	%
1. Number enrolled at beginning of semester	34	26	60	100
2. Promoted during semester	15	10	25	42
3. Number who were eligible for promotion at the end of semester	7	4	11	18
4. Total number responding to motivation	22	14	36	60
5. Total remaining in low sections during entire semester	8	4	12	20
6. Total number enrolled in "low" sections at the close of semester	29	21	50	—

Conclusions

The fact that 36 students, or 60 per cent of the enrollment, responded definitely to motivation, ought to be ample proof of the effectiveness of the sectioning plan as a motivation device. Such a large percentage of transfers may not be attributed to methods of teaching, no matter how superior the teacher or the methods may be.

The fact that the average class standing of the group remaining in the "low" sections was increased by approximately 20 per cent goes to show that students who have found their natural working level in these sections are not discouraged, but, on the contrary, are motivated.

While it is not supposed that the evidence presented herewith is conclusive, it does place the burden of proof upon those who declare that the sectioning plan, because of the more complicated task of administering it, does not justify its introduction.

SUCCESSFUL TEACHING

BY

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Successful teaching can be defined in more general and fundamental terms than that represented by the composite score on the typical teacher rating scale. According to Edward L. Thorndike, F. N. McMurray *et al.,* education means "change." The child has learned nothing unless he is as a result changed in some way. Thorndike says "learning is connecting; and teaching is the arrangement of situations which will lead to desirable bonds and make them satisfying." Dr. Frank Freeman says "it is not what is presented to the child which educates him, but rather the reaction that he makes to what is presented." According to this point of view, the successful teacher is one who arranges situations which bring about desirable responses on the part of his pupils.

What will it mean to evaluate teaching in terms of *change?* Suppose a pupil has studied English composition for a semester or a year, and the next year, when he is no longer studying composition *as such,* he does his writing as though he had never studied composition. That is, his writings are not materially different after studying composition than they were before. You may say "that teacher must have been a poor teacher." I agree, but I am not certain that we are thinking in the same terms. You may assume that she was not master of the subject matter. I am assuming that she was. Let us say that the materials of composition were presented in the accepted manner. In accordance with the above statement of education in terms of "change" or responses the pupil was not taught composition.

We may contend that we have always judged teaching in terms of responses or change, but in most cases we have assumed that if the teacher of, say, hygiene, has presented the subject matter

in such a way as to enable the student to reproduce it successfully on examination, that he is a successful teacher, regardless of the change or lack of change in the habits of the pupils. The boy who has used cigarettes for several years is a much greater teaching risk than one who has not formed the habit. Yet the boy has not been *taught* the harmful effects of cigarettes unless he stops using them.

If we take Freeman's statement literally we are forced not only to interpret teaching in terms of responses but to consider each pupil a special case. This does not mean necessarily that many teachers are to be rated as failures, but rather that those who are capable of getting results will be rated as artistic or professional. Acceptance of this point of view would mean no doubt that many a teacher who now rates himself successful when measured in terms of present day classroom standards would be aroused to greater effort to actually get results in terms of desirable change.

There are still a few doubting Thomases and scoffers to remind us that many aspects of education are unmeasurable, McCall's thesis to the contrary notwithstanding. Such criticism need not worry us unduly. In the long run the education program must be justified in terms other than norms on standardized tests, national or local, formal or informal in character. In other words, we teachers must not lose sight of the fact that our most significant task is to bring about desirable change on the part of our pupils. The layman judges our educational output largely in these terms. This is probably due to the fact that at present it often appears that little or no change is brought about by much of our teaching. It is true, of course, that the critics of the public schools often overlook " what is right with our schools " in their eagerness to make a case for " what is wrong with our schools." The successful teacher, in the eyes of the layman, is the one who brings about desirable changes in his pupils. Certainly the teacher of the future must be judged on some such basis. This statement is based on the assumption that the two great present day scientific movements in education may soon be brought together. When that happens the response criterion for successful teaching will have been brought very near home to educators.

I refer first to the ever increasing number of cost studies that are being made not only in institutions of higher learning but in the public schools as well. Such unit costs as per capita, student clock hour, and credit hour are now known by many institutions of learning. Second, to the scientific measurement movement in education, which means the tools for measuring the educational output of the school. Many schools now know fairly well what the educational output is in comparison with that in other school systems throughout the country.

The bringing together of these two movements means the speedy elimination of the unsuccessful teacher and administrator. The school of the future will more than likely be determined efficient or non-efficient in terms of the cost per unit of actual educational accomplishment. The scientific measurement movement is making great strides toward controlling the variables which at present prevent such an evaluation being placed on the typical school plant.

Naturally we should expect the school that is expending the most money per student to turn out the highest educational product, other things being equal. Already there have been a few such studies made, and it has not always followed that the schools expending the most money per pupil, after accounting for such variable factors as intelligence, have done the best job of teaching when measured in terms of cost per unit of educational output.

The time is almost past when school administrators can justify an increased budget without showing an increased educational return. The far-sighted administrator anticipates coming events and is prepared for them. The way to be prepared for the coming together of these two great movements is to see that the responses on the part of the pupils are commensurate with the cost of instruction.

Aside from the administrative exigency that confronts school administrators, teaching in terms of responses is worthwhile in itself. If we are to have a profession of teaching we must so judge our results. And if we are to become a worthy profession we must get desirable results in our chosen fields of educational endeavor. This, in many cases, demands a new type of teaching.

It means more sincerity, frankness, true fellowship in learning, more knowledge of subject matter, greater intellectual honesty, and genuineness on the part of the teacher.

A teaching motto might help us. If every teacher would take as a guide the following we should have a greatly improved type of teaching: "I shall teach for the far-off respect of my pupils." If I can have their good will and respect now, it will make my work very pleasant, but I *must* have it ten or twenty years from now after the acid test of time has been applied to my teaching.

If we need additional evidence to convince ourselves that we should rate our teaching in terms of responses, we might review briefly the teaching successes of a few of the great teachers. Christ, the greatest teacher, often said such things as "Go, and sin no more!" His teaching brought about change. Among the Greeks we might mention Socrates, Plato, and Aristotle as evidence of the definite influence of teacher upon pupil, from Socrates to Plato, and from Plato to Aristotle. We might mention further that Alexander the Great was a pupil of Aristotle's for several years, which doubtless accounts for the beneficent reforms which followed the conquests of Alexander the Great.

One of the best illustrations of the teacher's influence upon his students was that of Mark Hopkins, a recognized educational leader of his day, of whom James A. Garfield, in a tribute to the great worth of his teacher, said that *a log with a student at one end and Mark Hopkins at the other was his ideal college.*

Once we attempt to evaluate teaching in terms of responses we shall devise means for making our teaching more effective in the carry-over to life outside of school. Teachers will recognize that the school is responsible not only for the conduct of its pupils while in school, if right conduct is an objective of school training, but also while out in the community. Citizenship courses must actually make better citizens. When the majority of teachers can be called successful on the basis of desirable change in their students we shall have a worthy profession.

ASPECTS TO BE CONSIDERED IN THE ORGANIZATION OF A FIRST COURSE IN PSYCHOLOGY

BY

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Just what should be included in any first course of science has constituted one of the important problems in education, and as a science becomes more inclusive the question becomes more involved. Considerable evidence of the advantages of certain methods in presenting the subject matter has come from the research laboratories and has modified or caused revision of the content of many basic courses. Experimental education is the logical sequent of experimental methods in psychology developed by Wundt, Meuman, Ebbinghaus, Galton, Pearson, Cattell, and others, the difference being largely that of specialization on problems of efficiency and economy in learning certain kinds of material.

Most of the subject matter of science has undergone a decided change within the last decades, and even in the older categories considerable modification in the arrangement of content and methods of teaching have evolved. There are strong tendencies abroad to present the sciences in a general introductory way before teaching detailed technicalities. General science, general mathematics, and now general language courses are coming to be more or less common. Orientation courses in the natural and social sciences are offered in many universities and technical schools.

It seems, however, that psychology has been one of the last subjects to become the object of its own instigated researches. Too many psychologists have fallen into rigid habits of thinking—perhaps best for specific branches of the science—and have developed schools or methods which many times could or would not admit the newer and different concepts of psychological method.

Behaviorism has helped in breaking up these errors in thought but we still have two distinct tendencies in psychology. One of these is the gradual differentiation of pure psychology into the various specialized and applied branches, such as experimental, comparative, genetic, abnormal, psychiatry, social, educational, industrial, and others. Opposed to this trend is the more recent attempt of various authors to supply a suitable textbook which will properly introduce and synthesize the basic concepts of such a young and growing science. A demand has arisen for such texts in the 745 colleges of our country where psychology has recently become one of the leading required subjects. This demand has been strengthened by the growing number of junior colleges where the need for a well organized textbook is more urgent than in the advanced schools, since a more experienced teaching staff and closer supervision of the content of courses through examinations, quiz sections, or conferences, are usually maintained in the latter.

With the introduction of psychology as a required subject, the problem of whether it is to be an elementary or general course immediately arises. Only a small fraction of those students who take one course will ever reach the psychological research laboratory. Dr. Max Schoen (1) has sensed the need for a good practical course and has raised considerable objection to current methods of presenting a first course. Dr. Meyer (2) has not openly taken issue with Schoen but commits himself rather firmly for a strict method of offering a basic course in his review of seven recent textbooks.

The question seems to hinge on whether or not we are to have a strictly elementary science course (3) or whether we are to have a general course incorporating as many of the applied phases as is consistent with the introduction of psychology as a science. Many writers of textbooks seem to assume the latter tendency most promising, and considerable emphasis has been placed upon the practical side. Some universities are trying to remedy the situation by offering both an elementary and a general course, the general course being offered for advanced students majoring in

SOME ASPECTS TO BE CONSIDERED IN THE ORGANIZATION OF A FIRST COURSE IN PSYCHOLOGY

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other lines of work, and the elementary course being required of students doing major or minor work in psychology.

Several factors must be considered in organizing any basic course in science, and it is the purpose of this paper to present some experimental evidence on one of these factors (4)—although by no means the most significant—namely, the particular phases of a first course in psychology which seem most practical to the student considered in the light of his need—as he sees it. Student judgment as a criterion may be open to criticism, but in these days of elastic curriculae and many electives there could hardly be a marked agreement on the premise that a junior, senior, or graduate student would be utterly unable to decide, after taking an elective or a required course, as to whether or not certain aspects of that course were of more benefit to him than others.

Iowa State College has attempted to present an orthodox basic course in psychology, offered three hours a week for one quarter of twelve weeks. To most of the students the course is elective, but in all cases it is prerequisite to other courses in psychology. Standard texts such as Gates, Pillsbury, Seashore, Woodworth, and Watson have been used and the lecture method employed, supplementing the texts with demonstrations and up-to-date material which could safely be presented in a first course. An attempt has always been made to make the work practical but never at the sacrifice of a scientific point of view.

The following short study was made to discover, if possible, what students " feel " will be useful to them in their future work from material taught in their first course in psychology. At Iowa State College there are roughly some 2,000 students taking psychology during the year. Most have had their elementary work at this institution but many have had preliminary courses at other schools, as the student group comes from various parts of American and some foreign countries. The study involved 108 students selected at random who were enrolled at Iowa State College during the acedemic year and summer session, 1926–7. The students were of both sexes, all of sophomore, junior, senior, or graduate rank. The group represented the four divisions, Industrial Science, Home Economics, Engineering, and Agriculture, and had

their basic course under at least seven different instructors or professors. A minimum of 3,024 required responses from a list of twenty classified topics form the basis for the tabulations and accompanying tables. The following outline of topics was given out in mimeographed form to be checked and answered as a class assignment after being carefully compiled from lecture notes, textbook discussions, and a general plan for the basic course offered at this institution. The division into five parts was for convenience in scoring and classification of responses, and roughly approximates the amount of time spent on the respective sections in lectures and discussions.

Form I

The following questions are being asked concerning your first course in general psychology. Your suggestions with others interested in such courses may help to open up new fields of interest, methods of presenting the subject matter, etc. Kindly answer *all questions and indicate by headings of outline the particular answer to questions indicated.* (Example: Ia, IId, IIIb, etc., giving main and sub-headings which seem to you are to be considered in the question.) Space has been left for these headings. Fill out when you have time to think over the questions and return paper next class hour. *First read over outline.*

OUTLINE

I. Biological—Background.
   a. Racial vs. individual development. A study of animal life from amoeba to man and of the embryo from conception to maturity.
   b. Anatomy of nervous system. Study of neurone, how it operates, etc.
   c. Function vs. structures. Why we are built as we are.
   d. Heredity and environment. A discussion of the causes which make us what we are. Are they inherited or learned?

II. Gross study of the psycho-physical organism.
   a. Reflex.
   b. Instinct.
   c. Special aptitudes.
   d. Emotions, feelings and impulses.

III. Analysis of conscious processes and reactions.
  a. Sensation and perception.
  b. Attention, association, and memory.
  c. Reasoning, thinking, and imagination.
  d. Volition and judgment
IV. Modification of original nature.
  a. Theory of learning—neural basis.
  b. Motor vs. higher learning—habit formation.
  c. Laws of learning—use, disuse, effect, etc.
  d. Control of emotions—study of glandular reactions.
V. Synthesis of human traits—personality.
  a. Clearing terms—definition of personality.
  b. Psychology and home relationships.
  c. School and personality.
  c. Personality in business.

A suitable scoring blank was attached on a second page which facilitated the filling out of the sheet by the student in such a manner as could be objectively scored. Only the data relevant to the present study will be included here. The aim in the questioning blank was to sound the interest of the student, what his reactions were in terms of his needs, what he thought was essential and non-essential from his point of view and what he would have elaborated more or eliminated from the course. Further he was asked to comment freely on topics he desired to know more about, and in order to be assured of the validity and reliability (the two are here rather interrelated) of his answers as having specific connection in the outline he was asked to give three headings which would have direct bearing on the topics so suggested, indicating the first, second and third choice. By correlating chance halves of the responses of the questions and also one question with another, averaging and correcting these intercorrelations by the Spearman-Brown formula, the reliability was found to be $R = .87$.

QUESTIONS

(Give 1st, 2nd, 3rd choice of headings)

1. Which of the above headings do you consider most helpful to you in your work, prevocationally or vocationally? 1. .... 2. ..... 3. .....

2. Which topics might have been abbreviated in the course without causing serious loss for your purposes? 1. ..... 2. ..... 3. .....
3. Give headings which you think might have been discussed more fully to your advantage in the course. 1. ..... 2. ..... 3. .....
4. Give three everyday topics you would be interested in working on by way of experiment or report and indicate their particular relationship in the outline.

(Topic)	(Heading)		
a.	1.	2.	3. .....
b.	1.	2.	3. .....
c.	1.	2.	3. .....

The following table gives the percentage ratings for each topic —first, second, and third choices—and also a combined percentage of choices on each question. The percentage ratings for the main headings are given in the fifth column under each question. For details refer back to Form I.

TABLE I. *Percentage ratings on questions*[1]

Division of questionnaire	Question I					Question II					Question III				
	Choice %			Com-		Choice %			Com-		Choice %			Com-	
	1st	2nd	3rd	bined	Group	1st	2nd	3rd	bined	Group	1st	2nd	3rd	bined	Group
I.															
a. Racial	1.3	0.8	4.6	2.3		34.0	7.0	9.0	17.0		1.8	0.0	0.0	0.6	
b. Anatomy	3.4	0.0	4.0	2.3		16.0	17.1	2.7	12.1		2.5	0.0	1.0	1.1	
c. Function	2.7	0.8	3.2	2.3		16.0	14.4	11.5	11.1		1.8	0.0	1.0	0.8	
d. Heredity	11.0	1.4	7.4	7.0	13.9	3.5	2.3	13.5	6.6	46.8	9.1	5.5	1.0	5.3	7.8
II.															
a. Reflex	0.7	1.4	2.0	1.3		8.0	12.3	9.9	10.3		0.0	0.7	0.0	0.3	
b. Instinct	1.4	1.4	2.0	1.5		2.4	6.2	1.7	3.6		2.5	1.5	2.1	2.1	
c. Aptitudes	2.0	2.8	1.6	2.0		2.4	7.1	3.4	3.9		1.8	4.5	7.2	4.4	
d. Emotion	2.0	5.5	3.5	4.0	8.8	4.2	5.2	1.7	3.7	21.5	1.8	2.3	6.1	3.2	10.0
III.															
a. Sensation	5.4	3.5	2.7	4.0		1.6	2.5	6.2	3.6		2.5	3.1	10.4	5.1	
b. Attention	12.0	10.0	6.6	8.0		0.0	1.6	5.4	2.4		5.0	7.7	6.2	6.2	
c. Reasoning	12.6	11.0	7.2	9.9		0.8	1.6	4.4	2.4		5.0	8.7	10.4	8.1	
d. Volition	6.0	2.8	3.4	4.4	26.3	0.0	4.4	9.9	4.8	13.2	3.5	8.7	7.2	6.5	25.9
IV.															
a. Neural	6.6	7.4	4.0	7.0		2.6	1.6	6.2	3.6		5.9	8.0	0.0	5.1	
b. Habit	3.4	7.4	8.0	7.0		1.6	1.6	0.9	1.3		5.0	7.1	6.2	6.2	
c. Learning	6.6	7.4	12.6	4.9		1.6	1.6	0.0	1.2		5.0	6.2	2.1	4.7	
d. Control of emotion	3.4	6.0	6.6	6.0	24.9	2.6	2.5	0.9	2.4	8.5	5.0	8.0	9.3	7.4	23.4
V.															
a. Personality	3.4	6.8	4.0	5.0		0.8	3.2	3.5	2.5		6.6	5.3	4.1	5.6	
b. Home	2.7	6.0	5.4	5.0		0.0	1.6	5.4	2.4		7.8	8.0	4.1	6.8	
c. School	5.5	8.8	4.6	7.0		1.6	3.2	1.7	2.4		11.8	9.3	10.4	10.8	
d. Business	8.3	7.4	7.2	9.0	26.0	0.8	2.6	1.7	1.8	9.1	15.4	6.3	11.6	11.4	34.6
Totals	100.4	99.6	100.6	99.9		100.5	100.0	99.5	99.1		99.8	100.8	100.7	100.6	

[1] Question I, most helpful. II, might have been abbreviated. III, might have been elaborated to advantage.

TABLE II. *Topics on which students wish more information given in the first course in psychology. (The topics are arranged in order of preference and the values are given in per cent)*

Topic	Per cent
1 Personality	7
2. Heredity and environment	7
3. Memory	7
4. Learning	6
5. Intelligence testing	6
6. Vocational guidance	5
7. Methods of study	5
8. Genetic psychology	5
9. Control of emotions	5
10. Attention	4
11. Individual differences	4
12. Thinking and reasoning	3
13. Habit formation	3
14. Perception	3
15. Methods of teaching	2
16. Understanding people	2
17. Instincts	2
18. Outside activities	2
19. Advertising	2
20. Sensation	1
21. Music	1
22. Crime	1
23. Athletics	1
24. Psychology in business	1
25. Dreams	1
26. Character in education	1

Topics showing less than 1 per cent

27. Influence of glands
28. Understanding of friends
29. Knowledge of self
30. Salesmanship
31. Imagination
32. Reaction time
33. Divorce
34. Custom and public opinion
35. Psychology of mathematics

Topics showing less than ½ per cent

36. College leaders
37. Dancing
38. Dress
39. Loyalty
40. Religion
41. Judgment
42. Anatomy of nervous system
43. Economics

From the above data given in Table I we note that students in a technical school such as Iowa State College take courses in psychology for the practical reasons, and a course which would satisfy the requirements of such students—"as they see it"—would conform rather closely to the suggestions offered by Schoen. It is not to be expected that the above facts would be true of all types of schools in the country, but a compilation of more data from other sections would materially aid in localizing weaknesses in such courses.

In Table II we give a tabulation of the relative frequencies of suggested topics of special interest to the student. A total of 336 suggestions were offered. A careful comparison will reveal the striking predominance of interest in certain phases of psychology. On the whole these students favor a study of mental life as such and do not appreciate the physiological connections necessary to a basic knowledge of the working of the mind.

Summary

1. A group of 108 students in a technical school were studied in reference to their reactions to their first course in psychology.
2. Average correlations of parallel forms examination by correction showed a reliability of .87.
3. The responses seem to favor the elaboration of the following topics given in order of merit:
   a. Knowledge concerning influences of heredity and environment.
   b. Memory, attention, association, reasoning, thinking, and conscious processes.
   c. Knowledge of how we learn, laws of learning and their application.
   d. Control of emotions.
   e. Influence of personality in school and business.
4. The following were looked upon with disfavor and were thought to be considerably overemphasized:
   a. Discussion of ontogenetic and phylogenetic development of the organism, the nervous system, and physiological psychology.
   b. Consideration of the reflex and its functioning.
   c. Instincts.
5. Similar studies in other institutions are suggested as a means of adjusting the first course in psychology to present needs.

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THE DETERMINATION OF A GENERAL FACTOR IN RESEARCH ABILITY OF COLLEGE STUDENTS

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The purpose of the present study is to determine the extent to which a general factor may underlie the various special abilities involved in research. The special abilities considered in this study are those indicated by the Iowa rating scale which was designed by Seashore as an objective method of selecting graduate students on the basis of certain special abilities regarded as necessary for success in research. The special abilities selected and the scale of values based on 100 per cent are represented as shown in Table I.

Now, if as Spearman (1) maintains, there is a common function or group of functions underlying the various intellectual activities of students, then we may assume the presence of some such common ability as research in the scale of abilities just now referred to. Spearman's theory is to the effect that " whenever the tetrad equation holds throughout any table of correlations, and only when it does so, then every individual measurement of every ability (or of any other variable that enters into the table) can be divided into two independent parts which possess the following momentous properties. The one part has been called the ' general factor ' and denoted by the letter g; it is so named because, although varying freely from individual to individual, it remains the same for any one individual in respect to all the correlated abilities. The second part has been called the ' specific factor ' and denoted by the letter s. It not only varies from individual to individual but even for any one individual from each ability to another."

The tetrad equation results from the following relation existing among any group of coefficients of correlation:

$$\frac{r_{13}}{r_{24}} = \frac{r_{23}}{r_{14}} \qquad (1)$$

TABLE I. *Iowa rating scale of research abilities.*

Name of person rated.....

Name of person making the rating.....

Rate the student in each of the qualities listed below on the basis of 100%.

	Very Poor 10% 0% 10%	Poor 20% 10% 30%	Low Average 20% 30% 50%	High Average 20% 50% 70%	Excellent 20% 70% 90%	Superior 10% 90% 100%
1. *Reasoning power:* capacity for solving problems, both deductive and inductive.....	.....	.....	.....	.....	.....	.....
2. *Originality:* creative imagination brilliancy, planful initiative and fertility or rational ideas	.....	.....	.....	.....	.....	.....
3. *Memory:* extensive, logical serviceable, and ready command of facts.....	.....	.....	.....	.....	.....	.....
4. *Alertness:* quick, incisive, and responsive observation, thought and feeling.....	.....	.....	.....	.....	.....	.....
5. *Accuracy:* precise, keen, regular and reliable observation, thought, and feeling.....	.....	.....	.....	.....	.....	.....
6. *Language:* the use of accurate, terse, and lucid English	.....	.....	.....	.....	.....	.....
7. *Application:* power of concentration, sustained attention, persistence, and well-regulated effort	.....	.....	.....	.....	.....	.....
8. *Coöperation:* capacity for intellectual companionship, team work, and leadership.....	.....	.....	.....	.....	.....	.....
9. *Moral attitude:* intellectual honesty, wholesome moral standards, ideals and influences.....	.....	.....	.....	.....	.....	.....
10. *Health:* nervous stability, physique vitality, and endurance.....	.....	.....	.....	.....	.....	.....
11. *Zeal for investigation:* deep interest in and craving for original and creative work.....	.....	.....	.....	.....	.....	.....

where the subscripts represent any four of the abilities in question and the r's the coefficients of correlation between them. Now, if we assume that the correlations were derived from some 'entire population,' we may express this relation thus:

$$F = r_{13}\, r_{24} = r_{23}\, r_{14} = 0 \qquad (2)$$

Furthermore, since the true value of the tetrad difference is always zero as shown in the tetrad equation (2 above) then the observed values when the entire population is replaced by a sample, will not be always zero but will deviate from this value and we have

$$\text{Mean } F = 0\ (\pm \text{ the error of sampling}). \qquad (3)$$

The formula for finding the error of sampling is:(2)

$$F = 2\sqrt{\frac{r^2\,(1-r)^2}{N} + \frac{s^2}{N}} \qquad (4)$$

where S = standard deviation of all r's, r = mean of all r's, and N = population.

Spearman, Holzinger and others have demonstrated the success of this criterion in a wide range of physical and mental abilities.(2) Wilson applied the same criterion in a study of interests of college students and found a very close agreement (Mean F = 0.0043; r = 0.0266) with the theoretical expectation of the foregoing hypothesis.(4)

For the purpose of this study a group of 200 students in General Psychology were instructed to rate each other on each of the eleven traits listed above. To insure as high a degree of reliability of judgment as possible by the method of rating, each student was told to rate six of his associates whom he knew best. And furthermore, in order to eliminate, as far as possible, the error of halo,(3) *i.e.*, the influence of the rater's general impression of the individual rated, the definition of each ability was carefully read and emphasized.

Since each sex taken alone probably presents a more homogeneous group than the two sexes combined it was decided to consider the ratings of the men and women separately. For the

present purpose only men were included and no student's record was selected unless it included the ratings of five or more associates. On this basis 90 men were selected whose ratings varied from 5 to 14 with an average of 8 ratings. The average of the whole number of ratings on each ability considered separately (not the average of all the abilities) was taken as the measure of that ability for a particular student. These average ratings, then, furnish the data upon which our analysis of research ability is based.

From these average ratings coefficients of correlation between every ability and every other ability included in this study were obtained. These coefficients are presented in the following table:

TABLE II. *Intercorrelations.*

	1	2	3	4	5	6	7	8	9	10	11
1....		64	66	61	72	52	58	50	33	24	58
2....	64		51	63	53	51	53	68	43	36	49
3....	66	51		64	71	59	62	43	31	25	65
4....	61	63	64		72	37	55	63	34	39	53
5....	72	53	71	72		57	76	43	49	19	57
6....	52	51	59	37	57		67	33	42	14	52
7....	58	53	62	55	76	67		27	26	11	72
8....	50	68	43	63	43	33	27		44	51	39
9....	33	43	31	34	49	42	26	42		33	41
10....	24	36	25	39	19	14	11	51	33		26
11....	58	49	65	53	57	52	72	39	41	26	

It will be observed from this table that the correlation of trait number 10 (health) with all other traits except number 8 (co-operation) is low or negligible. Thus ratings on health show only a slight tendency to correlate with those on intellectual, emotional and moral traits. While health represents an important asset for success in research, it is obvious that the per cent of health possessed by an individual is far more difficult to estimate than the same measure of reasoning ability, memory, initiative, etc.

It follows that the rating of the individual's health should be made only by those companions who are familiar with a considerable period of his history and know him intimately, or by a physician.

The mean of all r's is 48; S.D., .119. The mean of all the remaining r's when trait number 10 is excluded is 53; S.D., .102. Those traits yielding the highest correlations are reasoning ability, originality, memory, alertness, accuracy, language, application. The correlation of coöperation with originality and alertness is moderately high. With all other traits except health the correlation is low. Moral attitude yields low correlations with nearly all other traits. These facts indicate that when considered together with intellectual abilities such traits as coöperation, moral attitude and health although important for research do not seem to possess a common factor to the same extent as in the case of intellectual abilities. It is interesting in this connection to note that zeal for investigation yields a fairly high correlation with all the traits in question except coöperation, moral attitude and health. The explanation of this may possibly be found in the assumption that a rater who sets a high value on a student's reasoning power, originality, alertness, application, etc., will interpret these special abilities in terms of "deep interest in and craving for original and creative work." If so, we have here a suggestion of some common factor functioning in these various special abilities.

The tetrad equation was next applied to these coefficients to determine the extent to which the data in question fulfill the requirements of the general ability theory as stated above. The total number of tetrad differences obtained from the 55 correlations is 990. The distribution of these gives the following results:

Theoretical mean F = 0.0000; S.D. = 0.0624
Observed mean F = 0.0198; S.D. = 0.1322

Thus, it is seen that no very close agreement exists between these observed values, mean and standard deviation, and those demanded by the normal probability curve. The observed standard deviation which is more than twice that of the theoretical deviation cannot be attributed merely to sampling errors. Among

the disturbing factors which undoubtedly entered into the table of intercorrelations may be mentioned (1) the small number (90) of subjects in this study, (2) the inadequate number of judgments on each trait, and (3) the relatively greater difficulty of estimating the numerical value of such traits as coöperation, moral attitude and health as compared with intellectual abilities.

Distribution of tetrad differences

−.45	−.40	−.35	−.30	−.25	−.20	−.15	−.10	−.05	−.00
1	3	4	14	15	31	56	80	131	181
+.05	+.10	+.15	+.20	+.25	+.30	+.35	+.40	+.45	+.50
165	132	71	48	21	19	8	9	0	1

Although the agreement between observation and theoretical demand as demonstrated in this study is by no means perfect, the tendency toward conformity between the observed and theoretical distributions as shown by the general shape of the observed distribution (see above) justified the belief that some general factor, call it "general intelligence," "mental energy" or what not, does underlie in some degree the special abilities which are assumed to constitute capacity for research. This belief is further supported by the fact that all the correlations are positive. Anything approaching a positive conviction must wait upon more reliable methods of measuring such complex traits as initiative, coöperation, moral attitudes, health and zeal for investigation. Meanwhile, this tentative belief in a common factor in research ability should stimulate further and more extended investigation of this interesting and important theoretical problem. An important approach to the problem may well be the analysis of the special, though highly complex, abilities assumed to represent capacity for research and a careful definition of each component entering into the complex trait. Further, if the rating method is to be used, it must be refined in such a way as to provide for the careful isolation of individual traits and components which constitute complex abilities. In this way, it is to be hoped, an important step may be taken towards supplying the

psychology of personality directed to a special field of endeavor, namely research, with a genuinely scientific basis.

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WHAT IS THE VOICE VIBRATO?

BY

MILTON METFESSEL

Research on the nature of the voice vibrato, which for identification purposes may be described as that agreeable pulsing heard in singing, has been concerned with muscle action, the sound wave, and the sound heard.[1] This report deals with the sound wave, which has a dual interest for the psychologist, since its properties may be directly related to aspects of muscle action in vocal expression or to attributes of auditory experience.

Measurements of the vibrato on the sound wave would include wave-frequency, wave-amplitude, wave-form, and wave-recurrence (any temporal groupings of sound waves). We will here consider only the first and last. There is at hand measures of the amplitude of the waves in nearly all the tones of this study, but these were not considered reliable. Other than noting a change of wave-form with a change of frequency in most vibratos, no quantitative data on wave-form has yet been secured.

There are a number of different situations in which the vibrato occurs, viz., in untrained, in trained, and in what is ordinarily called artistic singing. This study has been limited to the latter, eleven artists from basses to sopranos being chosen from the Victor Red Seal catalogue.

There are only three published experimental contributions of note on the nature of the vibrato. The work of Schoen,(1) Kwalwasser,(2) and Gray (3) will be referred to in connection

[1] Since a monograph on the vibrato is in an advanced state of preparation, the present purpose will be to give a general vista of the subject by way of introduction. Other than inquiries into its physiological, physical, and psychological nature, the problems on which there is material include the place of the vibrato in artistic singing; a comparison of the vibrato with the tremolo and trill; the relations of the vibrato to faster fluctuations sometimes superimposed; the effect of the emotions on the vibrato; its development, natural and trained; racial comparisons; individual and sex differences; norms of acceptable vibratos, determined from artistic singers and by synthetic production by a siren; and a general study of its aesthetics.

with the present results. Schoen, however, is the only one who made a study of vocal artists from phonograph records.

Technique of measurements. The tones were photographed from the phonograph records by a technique previously described.(4) The sound waves so pictured were measured by the wave-length method,(5) using a transparent glass with millimeters ruled. The wave lengths were then plotted on a scale with equally spaced half steps vertically, each wave length being given the same distance from left to right.

The vibrato came out as a cycle of successive frequencies, that is, the trough of the cycle might be on C, and the crest on C♯. The first step in a measurement of these cycles was to smooth them into four straight lines by the following procedure: Four straight wires were laid on each of two cycles for each operation, and adjusted for the best schematic representation of these cycles. One wire was placed on the crest, another on the trough, and others on the connections between crest and trough in the cycle. Each wire was laid on the judged center of the wave-length plottings of its own section (trough, crest, etc.), the trough and crest being parallel to the horizontal axis of the graph. The four points of crossing of the wires were then marked on the first of the two cycles, the second acting as a base for the point common to both of them.

The justification for this procedure of treating and smoothing vibrato cycles lies in its simplicity for quantitative studies, and in tests applied to smoothing the same cycles at different times, resulting in insignificant variations.

These cycles were then measured for three main variables: (1) the distance from trough to crest, or cycle extent, (2) the duration of the cycle, or cycle length, and (3) the relationship of the crest (C), trough (T), and the connections between them (C-T, T-C).

Cycle extent was computed on the graph by a scale which divided a half step into five parts; cycle length by dividing the average of the wave-length values (in mm.) of the trough and crest multiplied by the number of waves in the cycle, into the number of mm. the film traveled per second; and form by dividing the number of waves of C, C-T, T, and T-C into the total

number of waves in the cycle, thus giving a value to each variable of form in terms of percentage of the whole.

Sampling. The data to be presented are based on the 615 vibrato cycles obtained from various Victor records as indicated in Table I. The tones chosen from these records consist of ran-

TABLE I. *Number of vibrato cycles studied and the source from which they were obtained*

No.	Name	Number of cycles	Victor Red Seal Records *
1.	Braslau	73	550–A; 6051–A,B
2.	Caruso	137	6000–A; 6001–A,B; 6005–B; 510–A,B; 514–A,B
3.	Chaliapin	89	981–A,B; 6057–A,B; 6489–A,B
4.	De Gogorza	26	1141–A; 6069–B
5.	De Luca	92	593–A,B; 6079–A,B; 6081–A,B
6.	Galli-Curci	78	6126–A,B; 6129–A,B
7.	Gluck	30	650–A; 655–A,B; 664–A; 6142–A,B
8.	Homer	13	683–A,B; 6170–A,B
9.	Melba	18	6214–A,B
10.	Schumann-Heink	28	835–A,B; 911–A,B; 6273–A
11.	Whitehill	31	852–A,B; 849–A,B; 6306–A,B
	Total	615	

* The precise data for each vibrato cycle, including its location on a phonograph record, is being reserved for the monograph mentioned in footnote 1.

dom samples as far as the vibrato is concerned. The records were selected from the stock of the local dealer on the basis of passages sung with little or no orchestral interference, and this probably has no connection with the vibrato. In some instances the vibrato had a faster fluctuation superimposed upon it, and such tones were rarely measured for this study. This should only reduce the total number of cases, and have little effect on the chance sampling of the cycles.

Cycle extent. In Table II we have the distribution and mean of the extents of the 615 cycles, the values being in per cent of a whole step. There is a fairly normal distribution from .10 to 1.00 step, centering about .50. Those above a whole step seem to be set off by themselves. One of the widest extents may be heard on the short tone at Rds. 218–219 [2] of Caruso's "Aida," No. 6000.

[2] The base for counting the rounds (Rds.) of the phonograph record is where the music starts. The record is slowed down, and the point where it begins playing is marked. From the start of the music to the instant the mark completes one round is called Rd. 1.

TABLE II. *The extent of the vibrato cycles in terms of a musical step*

Per cent of a step	Singer No. (cf. Table I) 1	2	3	4	5	6	7	8	9	10	11	Total
.10	1	1										2
.15	3				4					2		9
.20	3	3	3		1	2	1	1	1	3		18
.25	4	10	8	2	2	2			1	4	1	34
.30	8	10	9	5	3	6	6	2	4	4		57
.35	8	17	9	4	2	7	8		1	3	2	61
.40	11	18	4	2	3	9	7		1	2	6	63
.45	3	8	8	1	4	8	3		1	3	4	43
.50	9	15	9	6	7	13	2		3	4	5	73
.55	5	5	9	3	7	4	2		1	2	2	40
.60	8	7	7		6	14	1	1	3		2	49
.65	6	8	2	2	6	4			2	1	3	34
.70	1	7	7	1	17	3					2	38
.75		8	3		13	1						25
.80		8	2		6			5			3	24
.85	2	5	3		6	2					1	19
.90		2	2		1			1				6
.95		2	1									3
1.00		1			2			1				4
1.05						1						1
1.10			1		2							3
1.15		1						1				2
1.20	1	1	1									3
1.25								1				1
1.30						2						2
1.35			1									1
Mean	.45	.61	.52	.43	.62	.52	.39	.77	.44	.36	.53	.52

The narrowest tone of the group, with an average of .22 step for its six cycles, is Braslau's " Yohrzeit," No. 6051-B, Rds. 24–25. Schoen's statement that " there are marked individual variations " for the extent of the vibrato is quite in accord with these findings.

If the mean extents of the five men are averaged, the result is .54 step, while for the women the average is .49 step. This is one indication that the extent of the vibrato in terms of per cent of a tone is little dependent upon absolute pitch height. The same is true for relative pitch, as shown by Table III. The tones of

TABLE III. *Vibrato of Caruso and Galli-Curci compared*

	Lower range	Middle range	Upper range
Caruso	.58	.65	.60
Galli-Curci	.53	.47	.56

Caruso and Galli-Curci were grouped into three ranges, with the results as tabulated. The fact that there are no appreciable dif-

ferences in the lower and upper range confirms the statement in a previous article (4) that "the extent in terms of part of a tone is far more constant throughout the range of the voice than in terms of vibrations."

Gray (3) found that in speech "the extent of the fluctuation varies from less than one-fourth of a tone to two full tones." The wide extent he mentions is interesting in view of the fact that among our artists the widest extents occur on short tones of singing.

Cycle length. The distribution and means of the cycle lengths are shown in Table IV. Although the range of the separate cycle lengths is from .095 sec. to .195, there is no complete tone averaging as slow as five cycles per second, or as fast as ten.

TABLE IV. *The duration of the vibrato cycles*

	Artist											
Sec.	1	2	3	4	5	6	7	8	9	10	11	Total
.095					2							2
.100		1		2								3
.105			1	1	2	1	1		3	2		11
.110	1		1	3	1	2	1			1		10
.115		1		3	2	1	1		1	1	1	11
.120	1	9	2		3	5	7				1	28
.125	1	9	5	3	1	3	4		1	2	1	30
.130	4	12	4	6	8	6	1		2	7	3	53
.135	8	11	9	3	7	15	5	1		4		63
.140	7	29	16	1	5	13	2	2	3	3	4	85
.145	6	13	22	2	17	6	3	2	4	1	2	78
.150	16	18	13		7	14	2	2	1	3	5	81
.155	7	13	3	1	9	8	2	3	3	1	5	55
.160	9	10	7		5	3				1	3	38
.165	4	5	5		11	1					5	31
.170	5	3	1		6		1	2		2	1	21
.175	3	2			1			1				7
.180	1				3							4
.185		1		1	1							3
.190												
.195					1							1
Mean	.152	.145	.146	.129	.149	.134	.154	.137	.139	.139	.152	.145

The fastest average vibrato on a given tone is 8.7 per second, and occurs in De Gogorza's "Faust," No. 6069-B, Rd. 268. The slowest is 5.6 and is found in De Luca's "O Carlo, Ascolta," No. 592-B, Rd. 178.

Kwalwasser and Gray both have somewhat similar results as to rate. The former found that "the rate of pulsations is quite

variable," and " in defining the vibrato it is necessary to state that the vibrato consists of an observable periodicity . . . varying in rate of occurrence from 4 to 9 per second." Gray concludes that for the vibrato in speech " the rate varies from 4.4 to 10 per second, these being extremes. The average is probably close to 6.4 per second." In comparing these results with the present, it will be remembered that these two studies were not limited to artistic vocalists.

Cycle form. By observation there seemed to be four outstanding types of form. The first, and the most frequent in occurrence, has a long crest, a short trough, and about equal connections, in the relationship exemplified by 46%C – 18%CT – 14%T – 20%TC. These numbers represent the average of a tone at Rds. 224–225, De Luca's " Herodiade," No. 6081. The second type has approximately equal sections, exemplified at Rd. 23 of Caruso's "Aida," No. 6000, with an average of 25%C – 26%CT – 24%T – 18%TC. The third may be stated typically as 19%C – 35%CT – 13%T – 32%TC. Trough and crest are almost alike, and the same is true of the connections CT and TC, but the latter are considerably longer than the former. The fourth type is rare, having a short crest and a long trough, as in Chaliapin's " Sonnambuli," No. 981, Rds. 10–11, 23%C – 21%CT – 37%T – 18%TC.

TABLE V. *The relative proportions of form in the vibrato cycles*

	Crest	Crest to trough	Trough	Trough to crest
Braslau	.32	.22	.25	.21
Caruso	.30	.23	.24	.23
Chaliapin	.29	.24	.22	.25
De Gogorza	.35	.20	.22	.23
De Luca	.25	.26	.26	.23
Galli-Curci	.27	.25	.24	.24
Gluck	.37	.21	.21	.21
Homer	.23	.27	.24	.26
Melba	.28	.20	.30	.22
Schumann-Heink	.30	.22	.27	.21
Whitehill	.32	.24	.22	.22
Total average	.29	.24	.24	.23

In Table V, the averages of the four variables in form are given, each in per cents of the entire cycle. The average vibrato

TABLE VI. *The variability of successive vibrato cycles for the different artists studied*

Artist	Row	Cycle Length (h.s.)	Extent (whole step)	Crest	CT	Trough	TC
				(Per cents of entire duration of cycle)			
Braslau.....	A	.011	.14	6.5	2.8	5.5	3.9
	B	.009	.07	3.8	1.8	3.5	3.2
Chaliapin.....	A	.009	.17	8.2	5.2	5.1	5.3
	B	.008	.09	3.5	3.2	2.6	2.9
De Luca.....	A	.015	.16	6.8	5.0	6.1	4.6
	B	.008	.08	3.9	3.6	2.7	2.5
Galli-Curci.....	A	.010	.14	6.4	5.4	5.4	4.7
	B	.007	.06	3.8	3.8	3.3	3.2
Gluck.....	A	.012	.07	8.7	6.3	6.4	4.1
	B	.007	.04	3.7	3.1	2.3	2.3
Homer.....	A	.010	.23	7.8	6.8	3.5	4.6
	B	.007	.06	1.8	3.9	2.3	3.4
Melba.....	A	.014	.13	8.3	4.7	9.5	6.8
	B	.006	.08	4.7	3.8	4.7	5.1
Schumann-Heink	A	.012	.12	8.3	4.1	10.1	3.4
	B	.010	.07	4.0	2.6	2.9	2.2
Whitehill.....	A	.011	.12	6.2	3.7	6.4	5.2
	B	.007	.06	4.3	3.0	3.2	3.3
Entire group....	A	.012	.14	7.7	4.8	6.2	4.6
	B	.008	.07	4.3	3.5	3.4	3.4
Caruso.....	A	.011	.20	7.9	4.8	5.3	4.2
	B	.007	.08	3.3	3.0	2.6	2.3
	C	.009	.14	6.6	4.5	4.4	3.5
De Gogorza.....	A	.013	.11	9.5	4.8	5.1	4.4
	B	.007	.03	6.5	3.3	3.6	3.6
	C	.012	.10	8.1	4.0	4.2	4.1

thus has a crest which takes up 5 per cent more of the cycle than any of the other sections. This analysis of form shows that there is ordinarily a rhythm in the vibrato, most often an alternation of a long crest and short trough.

Regularity. The next phase of the problem is to study the relation of successive cycles in a tone, and in groups of tones. Stated otherwise, how regular are the recurrent cycles in a tone, and from tone to tone?

In Table VI the values in Row A for each artist refer to the M.D. of all the vibrato cycles grouped together. Row B is the average of all the M.D.'s of the separate tones of each artist. The purpose of this table is to compare the variability of successive cycles in all tones and in a single tone.

In no case is the variability of the vibrato cycles in a single tone as great as in the tones as a whole. This, however, is true of a normal distribution, when broken into parts such as these, the separate values for each part being drawn by chance. The cycles of Caruso and De Gogorza were drawn in chance order and placed in the same groupings of 2, 3, 4, 5, 6, etc., cycles as was true of the actual tones. The C row represents the chance averages. Again in each case the variability of the separate tones as they are is less on the average than the variability by chance. There is no exception in any factor of the cycle.

The crest with an average M.D. for the entire group (Table VI) of 7.7 per cent has a larger variability than any other form variable. The trough is next in variability with 6.2 per cent, showing that the variations are mostly a matter of crest and trough, and not of the connections between them. This is important from the standpoint of the action of antagonistic muscles in the vibrato.

Summary

The artistic vibrato may be partly described in terms of the sound wave as a cycle of frequency with the following characteristics:

1. An average extent of a half step, ranging from a fifth to more than a whole step from tone to tone.
2. An average rate of approximately seven cycles per second, ranging from five and a half to eight and a half from tone to tone.
3. An average form with a crest slightly longer than the trough or their connections, with four distinct types in order of frequency of occurrence: (a) long crest and short trough, (b) equal trough, crest, and connections, (c) long connections, but short trough and crest, and (d) short crest and long trough.
4. The vibrato is more variable in extent than in rate, the M.D. for the former being .15 step, or 33 per cent, and for the latter .8 cycles per second, or 11 per cent.
5. The vibrato is more regular in a single tone than in the tones of a singer as a whole.

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SEASHORE MEASURES OF MUSICAL TALENT

BY

HAZEL M. STANTON

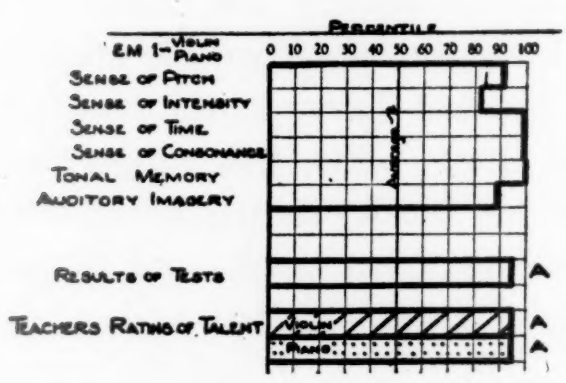
It seems fitting that my contribution to the special number of the *Psychological Review* which commemorates Dr. Seashore's thirty years at the University of Iowa should record the application of the Seashore Measures of Musical Talent in the Eastman School of Music. In September, 1921, when this school was organized, I became a member of the faculty as psychologist in music and began a program of testing. Test results and supplementary information were obtained from children and adults enrolled in the school, with little attempt made to use the results for a period of two years.

The *tests* consisted of the six measures of musical talent: (1) the sense of pitch, (2) the sense of intensity, (3) the sense of time, (4) the sense of consonance and dissonance, (5) tonal memory, and (6) auditory imagery. Supplementary information was obtained from students by means of a questionnaire, and from teachers by means of a rating form. The *questionnaire* filled out by students asked for reports of musical environment, musical training, musical activity, musical memory and imagination. The *rating forms* filled out by teachers asked for the ratings of each of their students in such factors as musical talent, musical feeling, tone quality, rhythmic action, application, and musical achievement. The rating of each of these factors was indicated by means of a check in one of six columns headed E, D, C—, C+, B, and A. These rating forms are filled out biannually by each teacher of instrument and of voice.

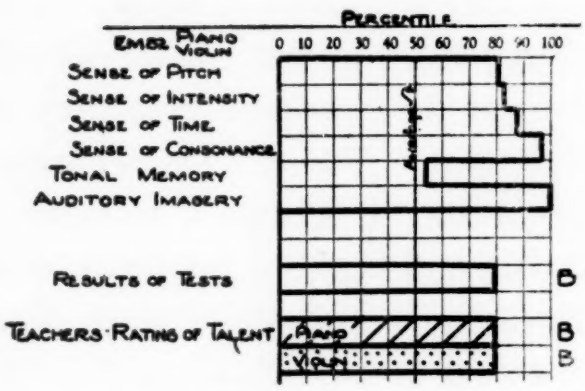
From this first information various studies were made of test results and teachers' estimates of talent. These studies were presented to the members of the faculty of the Eastman School of Music so that they might understand the significance of the tests

and their possible use in the school. This presentation, by means of lantern slides, was later elaborated and printed in a monograph published by the Eastman School of Music, The University of Rochester, Rochester, N. Y. Since this monograph is out of print, I wish in this contribution to review these studies briefly, and add other points that seem relevant.

As a basis for these studies test results are classified into A, B, C+, C—, D, E, with the highest classification A. Teachers' rat-



Profile 1



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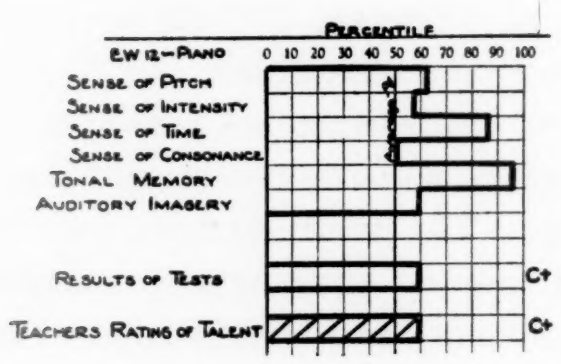

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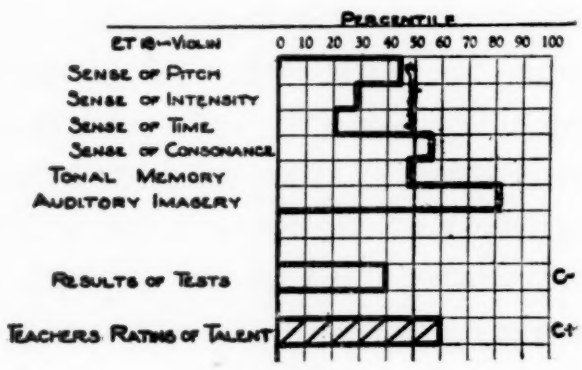

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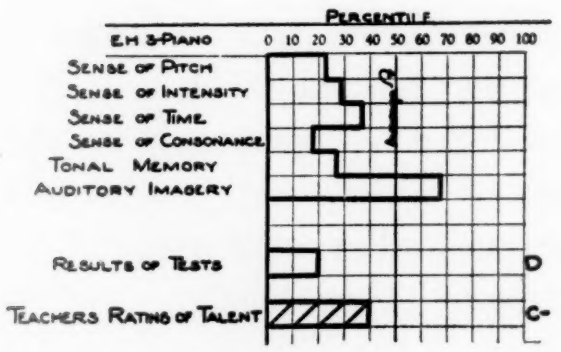
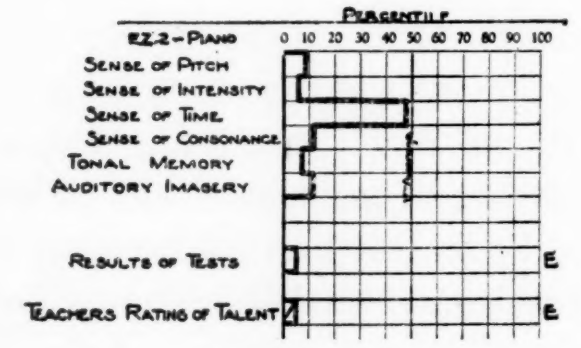


Profile 5



Profile 6

ings are expressed in terms of the same letters. All ratings by teachers were at this time and still are estimated without knowledge of the tests.

One of the first studies of the comparison of test results and teachers' estimates of talent was made by selecting individual test results at random from each of the classified groups of talent, such as A talent, B talent, C+ talent, C— talent, D talent, and E talent. One example of each of these six degrees of talent taken from the group chosen at random is shown by the graphic presentation of the talent profiles 1 to 6. The musical talent estimates of teachers are indicated below the profile. These examples will illustrate the consistency between test results and teachers' estimates of talent which was evident from the beginning. Striking similarities were apparent, not only between test results and one teacher's estimate of talent but between test results and many teachers' estimates of talent for various instruments and voice.

EM1 represents an A test profile with teachers' estimates of talent A for violin, A for piano. This student received an A rating for composition which is not shown on the chart. EM1 is a graduate of the school, makes music a vocation, and concentrates on composition. (Profile 1.)

EM52 represents a B test profile, with teachers' estimates of talent B for piano and B for violin. This pupil was ten years old at the time of testing and later discontinued from the school. (Profile 2.)

EW12 represents a C+ test profile with teacher's estimate of talent C+ for piano. Three later consecutive ratings of talent by the same teacher were B, B, and C+. This student was a candidate for the Eastman School of Music certificate, became interested later in voice study and opera. (Profile 3.)

ET18 represents a C— test profile with a teacher's estimate of talent C— for violin. No further ratings were obtained. (Profile 4.)

EH3 is an example of a D test profile with a teacher's estimate of talent C—. No further rating of talent was obtained. (Profile 5.)

EZ2 is an example of an E test profile with a teacher's estimate of talent E. This pupil discontinued after two months' study. (Profile 6.)

A second study was made with a group of 99 pupils for whom three classifications of talent were available, one by the tests, another by the director of the school, and a third by the pupils' private teachers. Distributions of these talent classifications into the five groups of E, D, C, B, and A are shown in Table I. Noticeable consistency is evident from these three sources of information. The tests place fewer cases in D and E and more cases in B and A than do the director and teachers.

TABLE I. *Ratings of 99 students by tests, by the director and by teachers*

	Number of cases					
	E	D	C	B	A	Total
Tests	0	8	45	37	9	99
Director	2	12	50	33	2	99
Teachers	0	14	56	23	6	99

This second study was followed by a study of the high 10 per cent and low 10 per cent of a group of 300 students tested the first year. Teachers' ratings of three factors, musical talent, musical feeling, and rhythmic action, were compared respectively with test results for the same students, the 30 highest according to tests and the 30 lowest according to tests. Table II shows the percentages of ratings by teachers for each of these two groups. For each of the three factors rated by teachers there is a paucity of ratings in D and E for those who tested high and a paucity of ratings in A and B for those who tested low. For those who tested high, teachers' ratings bulk in the upper part of the rating

TABLE II. *Percentages of teachers' ratings in musical talent, musical feeling and rhythmic action for the high test 10 per cent and the low test 10 per cent*

	Musical talent					
Tests	E	D	C—	C+	B	A
High 10 per cent	0	0	7	43	30	20
Low 10 per cent	13	47	27	10	3	0
	Musical feeling					
Tests	E	D	C—	C+	B	A
High 10 per cent	0	0	17	33	40	10
Low 10 per cent	20	57	17	6	0	0
	Rhythmic action					
Tests	E	D	C—	C+	B	A
High 10 per cent	0	0	10	37	43	10
Low 10 per cent	23	37	30	10	0	0

scale (C+, B, and A). For those who tested low, teachers' ratings bulk in the lower part of the rating scale (C—, D, and E).

The medians for the high 10 per cent (tests) and low 10 per cent (tests) are given in Table III for each of the six tests and for each of the seven factors rated by teachers. This consistency in the medians of teachers' ratings and the tests for the high group and low group emphasizes the fact that the tests tell us something which is in harmony with various teachers' estimates.

TABLE III. *Medians for the high 10 per cent and the low 10 per cent*

Tests *	High 10 per cent	Low 10 per cent
Sense of pitch	A (92)	D (21)
Sense of intensity	B (87)	D (23)
Sense of time	A (91)	D (24)
Sense of consonance	B (87)	C— (37)
Tonal memory	A (96)	D (20)
Auditory imagery	A (90)	C+ (52)
Teachers' ratings		
Apparent talent	B	D
Quality of tone	C+	C—
Rhythmic action	B	D
Musical temperament	B	D
Technique	B	C—
Achievement	C+	C—
Application	B	C+

* The numbers in parentheses are the medians expressed in percentile rank.

A similarly consistent correspondence occurred when the test results were distributed for all pupils whom teachers rated A and B in talent and those whom teachers rated D and E in talent. Those whom teachers rated A and B in talent tested from A to D with the most testing B, and those whom teachers rated D and E in talent tested from B to E with the most testing C— and D.

Further studies were made in January, 1924, of the permanence in the school of students who were tested during the academic year 1921–22 and in October, 1922. The percentages of A talent, B, C+, C—, D, and E talent remaining in the school during a two-year period are shown in Table IV. Of those who were tested during 1921–22 none of the D and E talent remained, approximately one-fourth of the C—, two-fifths of the C+, somewhat over one-half of the B, and two-thirds of the A talent remained in the school. For those tested October, 1922, the per-

centages of each talent remaining also increase from the lowest talent up to the highest talent. These facts show that the better talent remains in the school a longer period of time.

TABLE IV. *January, 1924, status of students tested 1921–22*

	Talent by tests					
	E	D	C—	C+	B	A
Percentages remaining	0	0	29	49	57	67

January, 1924, status of students tested October, 1922

	Talent by tests					
	E	D	C—	C+	B	A
Percentages remaining	0	11	57	70	75	92

When these first studies, comparing test results with teachers' estimates, were made, the personal equation of teachers' estimates was found to vary considerably. This variation is shown by the percentages of talent ratings of C+, B, A, made by twenty-three teachers of the piano department in January, 1924. These percentages are listed in Table V. The percentages of C+, B, and A talent ratings in January, 1924, vary from 84 per cent thus rated by teacher number 1, to 6 per cent thus rated by teacher number 23, a difference of 78 units. In these particular cases the first teacher gave no ratings in talent below C— and the last teacher gave no ratings in talent above C+. In order to adjust this difference, charts were sent to each teacher twice a year, charts which showed by means of columns the percentages of C+, B, and A ratings of talent given by all teachers in their respective departments, also giving the average for the department. As a result, the percentages for January, 1927, three years later, which are also listed in Table V, show a range of talent ratings with less

TABLE V. *Percentages of talent ratings C+, B, and A for the pupils of 23 teachers, in January, 1924, and again in January, 1927*

	Piano department											
Teacher No.	1	2	3	4	5	6	7	8	9	10	11	12
January, 1924.....	84	78	67	64	64	63	62	60	55	55	54	48
January, 1927.....	89	88	92	90	..	85	..	100	..	90	98	86
Teacher No.	13	14	15	16	17	18	19	20	21	22	23	
January, 1924.....	38	38	38	35	33	32	26	11	11	8	6	
January, 1927.....	69	..	82	..	..	61	89	79	68	..	84	

variation. The highest percentage of 100 was given by teacher number 8 and the lowest percentage of 61 given by teacher number 18, a difference of 39 units, one-half as great as that for January, 1924.

The average per cent of teachers' talent ratings of C+, B, and A for the piano department in January, 1924, was 45, and for January, 1927, it was 83, an increase of 38 points. The fact that ratings are higher in January, 1927, is not as significant as the fact that all teachers are rating within a range which is more consistent, one with the other. This means more fairness to pupils.

The percentages of tests of C+, B, and A for the pupils of these same piano teachers are presented in Table VI. These percentages are listed for January, 1924, and January, 1927, with the teachers numbered the same as in Table V. In January, 1924, the highest test percentage was 100, the lowest test percentage 65, a difference of 35 units. This difference is less than half the difference in teachers' ratings for January, 1924. In January, 1927, the highest test percentage is 95 and the lowest 82, a difference of 13 units. This difference is only one-third of that for teachers' ratings for January, 1927. Comparing the percentages for each teacher, the greatest difference, 21 units, occurs for teacher number 23 and the least difference, 1 unit, occurs for teachers numbered 3, 8, 13, 15, and 20.

TABLE VI. *Percentages of tests C+, B, and A for the pupils of the 23 teachers whose ratings of talent were shown in Table V*

Piano department

Teacher No.	1	2	3	4	5	6	7	8	9	10	11	12
January, 1924	80	76	86	86	100	83	88	95	82	85	76	74
January, 1927	89	93	85	95	..	92	..	94	..	95	86	89

Teacher No.	13	14	15	16	17	18	19	20	21	22	23
January, 1924	85	75	81	74	73	71	76	91	95	88	65
January, 1927	86	..	82	..	..	89	79	92	95	..	86

The next study of test results and teachers' talent estimates dealt with two selected groups. Up to the year 1924–25, 2,104 students had been examined. Out of this total 149 had tested D and E. Of these 149, only 20, or 13 per cent, remained in the

school September, 1924. For comparison, 149 who tested A and B were selected, and of these, 95, or 64 per cent, remained in the school September, 1924. The teachers' ratings of talent for these two groups are stated in Table VII.

TABLE VII. *Percentages of teachers' ratings of talent for 149 who tested A and B and for 149 who tested D and E*

Teachers' rating	E	D	C	B	A	No rating
Tested A and B.....	1	1	49	32	14	3
Tested D and E.....	7	14	45	1	0	33

From this study of 398 cases, 149 at either extreme of the testing scale, three facts are significant. First, of those who tested the lowest, D and E in talent, about one-eighth remained in the school, and of those who tested the highest, A and B in talent, about five-eighths remained. Second, of those who tested D and E, 21 per cent were rated D and E in talent by teachers and only 1 per cent were rated A and B in talent; for those who tested A and B, 46 per cent were rated A and B in talent and only 2 per cent were rated D and E in talent. Third, of those who tested D and E, 33 per cent never received a teacher's rating and for those who tested A and B, 3 per cent never received a teacher's rating.* When these facts were presented to the faculty of the Eastman School of Music in the fall of 1924 a unanimous vote was given that all those who tested D and E should not be admitted to the school, this action to take effect at once. This applied to all groups of students, such as preparatory, special, and regular course. Further restrictions have since been made for preparatory and special students with regard to retardation in school, amount of schooling, and age factors.

This completes a brief review of studies considered previous to the use of the tests for admissions. For the thousands of records in our files we now have one teacher's estimates of talent for the same pupil over a period of several years, also estimates from two and three different teachers for the same pupil over a period of time. These records furnish an abundance of data for further investigation.

* This means one of two things (1) they did not enter the school as planned or (2) they did not continue long enough to be given a rating.

There are three other studies in progress which I wish to mention and to record the steps taken in each up to the present time. No attempt will be made to state the details of these studies. The first two concern themselves with regular course students, the third one with preparatory pupils.

Of the two dealing with regular course students, one is the sectioning of freshmen on the basis of talent (tests) for the course in the theory of music. The tests used are the six Seashore tests: the sense of pitch, the sense of intensity, the sense of time, the sense of consonance, tonal memory, and the sense of rhythm; also an Iowa comprehension test. This battery of tests given to freshmen previous to entrance has made it possible to classify them at once in sections for theory. For a period of three years I have been experimenting with the reliability of these specific measurements for such a classification. Each year the effect of such grouping has been most serviceable and therefore encouraging, and will, no doubt, continue with such added points of adjustment as seem advisable.

The second study, involving regular course students, classifies all new students for the purpose of predicting success in the course. During the academic years 1924–25 and 1925–26 all freshmen were given one of five classifications. These five classifications were called *Discourage, Doubtful, Possible, Probable, Safe.* The classification affixed to each freshman was determined during the second semester of their first year, by considering all the first semester marks, the musical talent rank (tests), and the comprehension test rank. After assigning these classifications to a total of 225 students, the test combination was determined for each of the five groups of discourage, doubtful, possible, probable, and safe. By test combination I mean the combination of talent tests and comprehension test for each of the five groups. On the basis of such a test combination plan, I am able to recommend any applicant tested for the regular course as safe, probable, possible, doubtful, or discourage, and to make this recommendation immediately. Naturally the stability of such a recommendation will develop with the increase of students classified. The curriculum of the regular course was not suffi-

ciently stabilized until the year 1924–25 to begin such a study previous to that time. The test combinations for each of the five classifications will be published at some later time.

Now a few words in regard to the third study, which is one of retesting. Data for this study have been accumulating since the year 1924–25. All pupils and students who were tested during 1921–22 and remained in the school three years hence were retested. This policy of retesting after a three years' interim has been continued each year. During the academic years 1924–25 and 1925–26 all three groups were retested, including preparatory, regular course, and special. During 1926–27 only two groups, the preparatory pupils and regular course students, were retested. During 1927–28 only one group, preparatory pupils, will be retested. Up to the present time retests have been obtained for a total of 406 students, 177 pupils ranging in age from nine years to fourteen years, 106 pupils ranging in age from fourteen years to eighteen years, 22 special students, and 101 regular course students. Each person was retested in five measurements, making a total of 2,030 retests of specific capacities. The purpose of obtaining these results is primarily for a study of developmental capacity.

In conclusion I wish to express my own convictions regarding the Seashore Measures of Musical Talent. I feel keenly their unquestionable significance in determining the degree of an individual's musical capacity and have recognized repeatedly the permanency of their prognostic value. As far as their content and technique of construction are concerned they are not excelled. No other test material, to my knowledge, is possible to use year after year in its original form and yet retain its quality of newness and fairness for each person tested. And finally, the basic and fundamental factors measured represent an undercurrent of musicianship from which all musical expression and interest arise.

FIVE STUDIES OF THE MUSIC TESTS

BY

ESTHER ALLEN GAW

There are two objects in presenting this material. The first is to preserve the bits of information which have been obtained, because they are of real value. The second is to make a record of the fact that the research spirit in undergraduates may be fostered in classes in psychology.

In San Francisco I made much use of the music tests. This work lasted, however, only two years, and was with students just entering their normal course. Because they were very immature I did not succeed in getting the results from student coöperation that I realized later at Mills College. But at Mills my work with the music tests was purely incidental. I succeeded in getting many problems worked by students there, but in fields other than the music tests.

I present in this article the results of five studies in which students at both colleges coöperated. The studies fall into two groups, the first three made in San Francisco, (I) my own singing test, (II) a short form of the Time Discrimination Test, and (III) a short form of the Tonal Memory Test; and the last two made at Mills College, (IV) the intercorrelations of the five Seashore tests for Des Moines children, and (V) the results of the Pitch Discrimination Test on two kinds of reproducing machines.

I. SIGHT-SINGING TEST I

At the San Francisco State Teachers College in 1921–22, I was given the task of segregating and promoting the students in the normal training classes of singing. I needed objective tests for ability to read and sing, and had to devise my own. Following the specifications of the California School Music Series, I devised two tests, the first for elementary ability to sing at sight, and the

second for advanced ability. Both of these were useful tools during the two years I used them and seemed empirically reliable and valid. Since I have no statistical results of correlation between the Seashore tests and my advanced test, I will not include it in this report.

Singing Test I is made up of six parts, in which a total of 177 tones or items are to be sung. The test is given individually. Each one tested has a pitch pipe from which she can obtain her keynote. The examination itself is as follows:

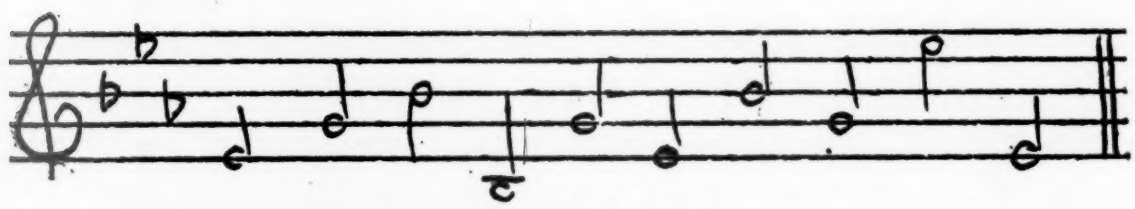
SINGING TEST I

Page 1. Directions: Do not turn this page until told to do so.

Page 2. Blank.

Page 3. Directions: Look this music through. Get the pitch of the key indicated from your pitch pipe. Sing the tonic chord. Then sing the following tones with the correct syllable names:

Part I

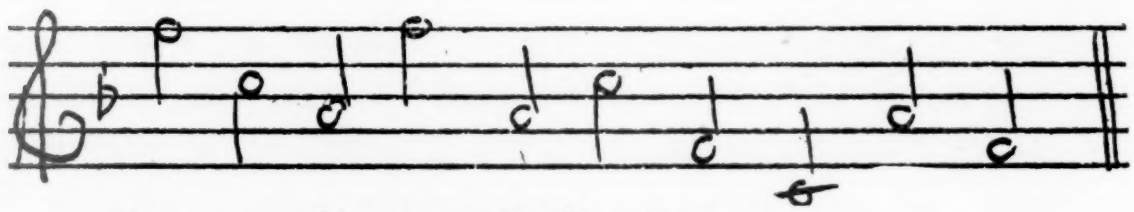


Do not turn this page until told to do so.

Page 4. Blank.

Page 5. Directions: Look this music through. Get the pitch of the key indicated with your pitch pipe. Sing the tonic chord. Then sing the following tones with the correct syllable names:

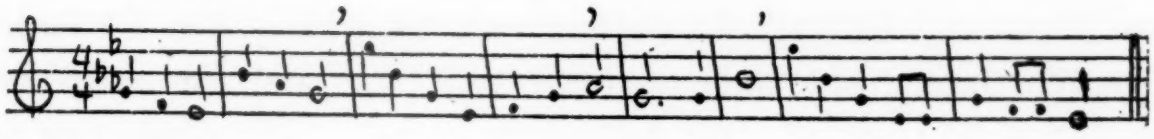
Part II



Do not turn this page until told to do so.

Page 6. Directions: In singing the following four songs (Part III, Part IV, Part V and Part VI) first get the correct pitch for the song from your pitch pipe. Then look carefully for the time signature and tap a few measures in the tempo indicated. Sing the song with the syllable names of the notes, giving careful attention at the same time to the time value of each note. Your ability to sing notes in time is being tested as well as your ability to sing the syllable names correctly.

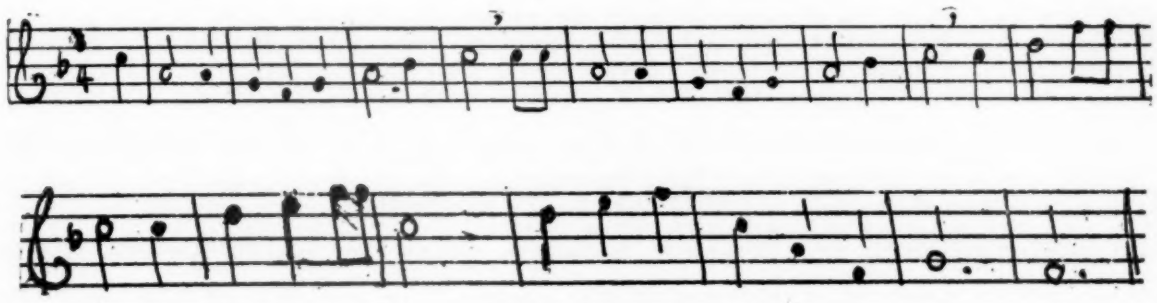
Part III



Page 7. Blank.
Page 8. Blank.
Page 9. Directions: Turn back to general directions on page 6 if you wish to read them again.

Get your pitch. Notice time signature and tap a few measures. Sing the song with syllables, giving correct time values as well as correct pitch.

Part IV

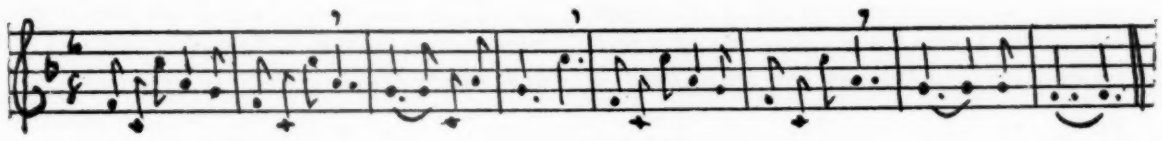


Do not turn this page until told to do so.

Page 10. Directions: Turn back to the general directions on page 6 if you wish to read them again.

Get your pitch. Notice time signature and tap a few measures. Sing the song with syllables, giving correct time values as well as correct pitch.

Part V



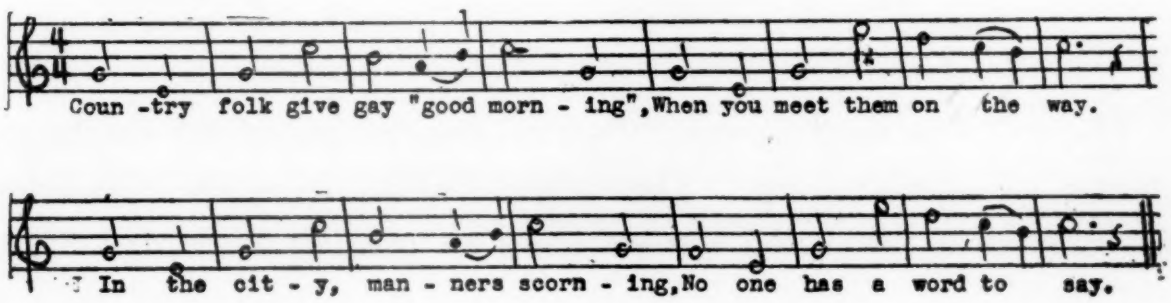
Do not turn this page until told to do so.

Page 11. Blank.
Page 12. Directions: Turn back to the general directions on page 6 if you wish to read them again.

Get your pitch. Notice time signature and tap a few measures. Sing the song with syllables, giving correct time values as well as correct pitch.

Sing the song a second time with the correct words, as well as correct pitch and time values.

Part VI



As will be perceived from the alternation of blank pages and test pages, the six parts of the test were so arranged in a booklet that the student saw only one part at a time, and she could not be distracted from her task by looking ahead. The conditions of examining were thus always controlled. The repetition of Part VI with words is included under the 177 items.

The score is the number of tones sung with correct intonation, syllable names, and time, or in the case of the repetition of Part VI, with the correct intonation, time, and words. If a tone occurs twice in succession, it is counted only once. Thus in Part III, measure 7, the *e*-flat eighth note on the last beat is credited only once. The errors in time were practically negligible.

While the student examined was singing, the writer was able to keep accurate account of mistakes in intonation and tempo. This was accomplished by holding a blank piece of paper beneath the music score and making accurate record of errors at the instant they were made. I had musical experience and skill and also intimate knowledge of the test myself. Such qualifications would be necessary for anyone wishing to use this test with success. The general distribution for the test results is given in Table I.

TABLE I. *General distribution of results for Gaw Singing Test I on 186 freshmen women from San Francisco Teachers College. Possible score 177. The score given is the midpoint of each respective group tested.*

Score	Per cent cases
175	6
165	20
155	15
145	17
135	13
125	7
115	5
105	5
95	3
85	1
75	3
Could not finish	5

The test was used as one of the criteria in sectioning the large classes in sight-singing. The other criteria were the Seashore discrimination tests and the evidence of musical training. The

results were empirically satisfactory, since we were able on the basis of these three sets of facts to group together students of approximately equal ability.

The test was used also in another way. It was divided into two parts, the first made up of items 1, 3, and 5, with a total possible score of 73, and the second part of items 2, 4, and 6, with a total possible score of 104. Half the members of a summer teachers training class gave items 1, 3, and 5 to the other half. In this way each member had the experience of giving, scoring, and evaluating the test. Although it is not justifiable to publish the results, since they were obtained by inexperienced examiners, they coincided in distribution very nearly with the findings when I made the examinations myself.

The correlations of this singing test with three of the Seashore tests and with the Beach (1) test are given in Table II. The

TABLE II. *Pearson correlation coefficients between results for Gaw Singing Test I, the Seashore Tests and the Beach Test. Data on 149 cases studied in San Francisco, 1921.*

	Pitch	Intensity	Memory	Beach	Singing I
Singing I	.46	.36	.56	.48	
Mean	76.8	85.2	67.1	59.1	132.6
Sigma	10.2	8.0	16.0	8.5	38.3

mean for the 149 cases used here is lower than that of the 187 cases in Table I. The 187 cases were summer school students, many of whom were experienced teachers. The difference in means is probably a real one.

The mean scores of the San Francisco group and percentiles of the Columbia Manual (2) show:

	San Francisco mean	Seashore percentile
Pitch	76.8	32
Intensity	85.2	29
Memory	67.1	35

The reason for the differences in all three tests, assuming that the San Francisco teachers should have an average score equal to the fiftieth percentile of Seashore, is obscured because the methods

of evaluation are not exactly identical. It is possible that a true difference between the Seashore group and the San Francisco group exists. The difference is made clearer by a consideration of the measures of spread, since Seashore's spread in terms of standard deviation can be estimated roughly from his percentile tables (2) by finding the scores nearest to the sixteenth percentile and the eighty-fourth percentile and taking half the difference. Estimating Seashore's standard deviations in that manner, they are:

	Score 16th percentile	Score 84th percentile	One-half difference or estimated sigma
Pitch	71	86	7.5
Intensity	81	93.5	6.25
Memory	57	88	16.25

Although the San Francisco means for Pitch and Intensity are lower than Seashore's means, they show a considerably greater deviation. In the case of the Memory test the whole distribution of scores is definitely lower in the San Francisco results.

The correlations of Pitch, Intensity, and Tonal Memory with Singing Test I seem to indicate that the three Seashore tests are diagnostic of singing achievement. The correlations are as high as the usual test and achievement relationships. Between intelligence and grades, for instance, the correlation is reported usually as being somewhere around +.50. If we should consider the objective singing test as the criterion and the Seashore tests as the measures, it is probable that a weighted scale based on multiple correlations would give a higher validity.

II. Modified Time Discrimination Test

The test for the Sense of Time (2) is exceedingly difficult for fifth grade children (see 3, p. 13, and 4, p. 11). The average per cent of correct judgments is 64, and those who merely guess are 17 per cent of the total number. It occurred to me that the three easiest differences in the test, namely, the differences of .20, .14, and .09 second, could be given and repeated, and that the other very difficult differences could be omitted for fifth grade children. This was done and the results are presented in Table III.

TABLE III. *Time Sense Test modified for Fifth Grade Children Score is mid-point of each respective step.*

Per cent right	No. cases	Percentile rank
95	2	100
90	5	96
85	7	91
80	14	70
75	6	46
70	5	34
65	2	31
60	6	21
55	4	7
50	2	3
Total	53	

In this form of the Time Sense Test there occur sixty judgments, since there are twenty on each degree of difficulty. The disc had to be turned over to the B side and the last ten judgments on .09 second difference must be found on the final fifth of the record. It is relatively easy for the examiner to become skilled in finding the proper place. The whole test is then repeated with the final result of 120 judgments, or 40 on each degree of difficulty.

The test was standardized and given in this way for a number of groups of children. Each percentile rank table was computed separately. The results obtained in at least four distinct examinations were strikingly similar, and the one given is typical. Unfortunately, I never pooled the scores of the various groups of children, not because of premeditation, but rather because that problem was always pushed aside by others. The more normal distribution, as seen when a comparison is made of Table III and the results of the Columbia Manual (3, p. 13), indicate that the test in this form, for children of the fifth grade, is a better one than the long test.

In San Francisco I always used percentile rank to indicate relative individual results, following Seashore's procedure. The cumulative method of getting percentile rank was used. That is, the cumulative per cent of cases at any point in the distribution, beginning with the lowest scores, was divided by the total number of cases to give the percentile at that point. All the percentiles given in this article are calculated in that manner.

III. Modified Form of the Tonal Memory Test

As in the case of the Time Sense Test, the original form of the Tonal Memory Test (2) does not give a good distribution for fifth grade children. More than one-half of the Des Moines cases get less than 65 per cent right (3, p. 15, and 4, p. 241). I therefore made a short form of the test, using the 2-span, 3-span, and 4-span portion, omitting the two very difficult spans, and repeating the entire series twice. That gave a total of ninety judgments, thirty on each span.

The results shown in Table IV indicate a normal distribution. The modified test seems to be difficult enough to distinguish fifth

Table IV. *Results for 141 children in fifth and sixth grades on the modified tonal memory test. Observations made in San Francisco and San Jose, 1922.*

Per cent right	No. cases	Per cent cases	Percentile rank
100	4	3	100
95	22	15	94
90	23	16	74
85	13	9	61
80	13	9	52
75	17	12	45
70	11	8	32
65	12	9	24
60	8	6	18
55	4	3	13
50	7	5	7
45	4	2	4
40	2	1.5	2
35	2	1.5	1

grade children from each other and not so difficult that a large proportion fail. Relative individual differences therefore have more meaning for this kind of a distribution than for that in the longer form of the test. In practical use I found this form of the test easier to administer than the harder form. The latter is so difficult that the children are easily discouraged and hard to motivate.

IV. Fifth Grade Norms of the Five Seashore Tests *

Seashore's fifth grade norms resulted from the scores of between 700 and 800 children of Des Moines. (3) In 1925, at

* With the aid of the class in Applied Psychology, Mills College, Fall of 1925.

Mills College, we made a study of those cases who had complete records in all tests. There were approximately 490 children, of whom 240 were boys and 250 were girls. Our study was primarily one of intercorrelation.

No intercorrelations of the results of the tests with children have to my knowledge been published. Seashore and Mount (5, p. 60) give the intercorrelations for adults when the tests were given on the original laboratory instruments. For purposes of comparison these are indicated in parentheses in Table V. Our

TABLE V. *Intercorrelations for the Seashore Tests used with fifth grade children in Des Moines. The figures in parentheses are correlations for adults.*

	Pitch	Intensity	Time	Consonance	Memory
Intensity	.82(.09)				
Time	.54(.17)	.95(.15)			
Consonance	.24(.21)	.08(.11)	.02(.07)		
Memory	.77(.52)	.63(.26)	.73(.17)	.17(.23)	
Mean	68.9	73.2	65.1	62.9	54.4
Standard deviation	10.0	6.9	8.3	9.2	16.3
Number	493	493	489	491	491

correlations, for the tests as given on the phonograph, are much higher in all cases except those of the Consonance Test.

In Table V we state also the Means and Standard Deviations which Seashore did not publish in his norms for the phonograph. We calculated these separately for the boys and girls and found almost no difference and so slight as to be insignificant. When we compared our mean scores to Seashore's percentile ranks as shown in his norms (2), our results were as follows:

	Mean (Gaw)	Corresponding percentile (Seashore)
Pitch	68.9	56
Intensity	73.2	48
Time	65.1	54
Consonance	62.9	58
Memory	54.4	58

It is to be remembered that the original scores used in calculating our results are included in the greater number of scores used for Seashore's norms. Ours were picked, being those of the children with complete records. Apparently those who had

incomplete records have relatively low scores in the tests which they actually finish. This, together with the differences in the method of calculation, would perhaps account for the discrepancies in the two measures of central tendency.

V. Pitch Discrimination at Mills College *

The Seashore test of Pitch Discrimination (2) for which norms are published (3 and 4) was standardized for the Columbia graphophone. Studies at the Iowa Laboratory had indicated that the norms were reliable for the other reproducing machines of the same general type, such as the Victrola and the Brunswick. There are no studies published showing a comparison between these standardized results and the recent types of machines, such as the Orthophonic Victrola and the Panatrope or the new Brunswick. The problem to be solved was whether the so-called improved type of machine would seriously affect the norms, and if so, whether the new machine would seem to make the test easier or harder.

The test was given at Mills College in September, 1926, to 249 entrants, first on the Brunswick which had been used during the preceding four years for this and other tests of the series. Then I repeated at the same sitting on the Panatrope, the improved type of Brunswick. The results are here presented. Table VI shows the comparative distributions in the norm for the Columbia, the

Table VI. *Comparative results from giving the Seashore Pitch Discrimination Test by different reproducing instruments.*

	Per cent of cases		
Per cent right	Columbia	Brunswick	Panatrope
95	1.0	0.4	1.7
90	12.0	19.7	26.1
85	30.0	41.0	40.6
80	24.0	25.6	18.5
75	4.0	7.3	6.4
70	8.0	2.0	2.0
65	5.0	2.8	2.4
60	3.0	0.8	0.8
55	2.0	0.0	1.1
50	1.0	0.4	0.0
45	0.0	0.0	0.4

The score is the midpoint of each respective step.

* With the aid of Lucille Fulwider and Claire Kirman, December, 1926.

Brunswick, and the Panatrope. The first is estimated from the graph in the Columbia Manual.(3) It will be seen that the mode (85 per cent of correct judgments) is the same in each distribution.

Table VII shows the Mean, Standard Deviation, etc., of the distributions. Those for the Brunswick and the Panatrope were calculated from the crude score data, and the probable errors were

TABLE VII. *Comparison between means and standard deviations for the results as gotten with three different reproducing machines.*

Number: 249 Mills College entrants (women).

	Columbia	Brunswick	Panatrope	Brunswick and Panatrope
Mean	81.0	82.7	83.5	
Standard deviation	7.8	6.2	7.1	
P. E. mean		.262	.303	
P. E. standard deviation		.187	.222	
r				+.732
P. E. r				.019
Difference of means				.8
P. E. difference of means				.405

estimated in the usual manner. The correlation between the scores obtained from the Brunswick and Panatrope tests were calculated by the Pearson formula.

The Mean and Standard Deviation of the Columbia norm in Table VII are merely estimated from the percentile rank tables in the Manual, but they are published as of interest for comparison with the statistically determined values of the other two distributions. For Columbia the score obtaining the fiftieth percentile is 81. Since the standard deviation indicates the range of the middle two-thirds of a distribution, we looked for those scores which are 16 below the highest percentile and the same distance above the lowest percentile, namely, for the 83 percentile and the 16 percentile. These are approximately the scores 86.5 and 71. The differences between these scores is 15.5. The estimated standard deviation is therefore one-half of that number, or 7.8. The Columbia distribution will be seen to be skewed, the difference between the fiftieth percentile and the upper limit of the middle two-thirds being 5.5, and that between the fiftieth percentile and the lower limit of the middle two-thirds being 10.

The ratio between the difference of the means of the Brunswick and the Panatrope and the probable error of that difference is 1.9. Since this is more than one probable error, the difference in the means is one that does not occur by chance. The Columbia mean, also, since it is even lower than those of the Brunswick and Panatrope, seems to indicate that the difference is not an accidental one. The correlation between the two forms of the test is high but not high enough to assure us that individuals would obtain scores in the same relative position whether given on one machine or the other.

My conclusion from this study is that the norm for the Panatrope is truly higher than that for the older type of machine. It may be that on the new type machine the observers are able to make slightly finer discrimination. Since the difference seems significant, it is unsafe to use the norms published in the Manual when the test is given on the Panatrope. The present norm might be substituted when the examination is given on the Panatrope.

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CORRELATION BETWEEN INTELLIGENCE AND MUSICAL TALENT AMONG UNIVERSITY STUDENTS

BY

GEORGE CUTLER FRACKER AND VIRGIE M. HOWARD

It is a problem of considerable interest to determine the relationship existing between the results for various tests of musical capacity and those for general intelligence. The earliest published results of this sort with which we are familiar are given in an article by Smith (1) where he states that the correlation between pitch discrimination and general intelligence for boys is positive .70 P.E. .023, and for girls .63 P.E. .026. It was his interpretation that a high correlation between pitch discrimination and general intelligence favored the hypothesis that doing well in the pitch discrimination measurements depended partly on ability to learn and therefore on the brightness and reliability of the subject. Seashore (2) has the following comment in relation to this problem and the pitch test: "Pitch discrimination can in no sense be used as a test of intelligence, for the physiological limit of pitch discrimination, the ear, does not vary with intelligence for normal individuals. The extremely dull person is, of course, more likely to give a cognitive limit than the bright person in the first measurement, but keen intelligence is by no means a guarantee of keen tone discrimination. This agrees with the fact that some of the most sensitive and responsive musicians find but little interest in intellectual pursuits; and that some intellects are notoriously devoid of a musical ear. Pitch discrimination is not a matter of logical judgment. It is rather an immediate impression, far more primitive than reflective thought, and dependent upon the presence or absence, in various degrees, of the sensitive mechanism of the inner ear."

From the theoretical point of view this analysis seems justified.

We may assume that after the individual becomes thoroughly familiar with the type of judgment he will approach the physiological threshold, and this we may expect to be quite independent of the intelligence level. However, during the very first experiences and perhaps extending to the first taking of the test by a subject, the subject's intelligence will be operative as a factor in his understanding coöperation.

Hollingworth (3) has given us an interesting report of significance on this general question. A group of forty-nine intellectually gifted children, with I.Q.'s of 135–190 and an age range of eight to eleven years five months, were given the Seashore music test and compared with the Seashore norms for fifth grade pupils. From their results they were able to conclude that "above the level of intelligence required to understand and perform the Seashore test (mental age of about ten years), performance in pitch discrimination, perception of intensity, consonance and tonal memory is not symptomatic of intellectual endowment." These pupils met intelligence test situations much better than the average for people of their age but met the music test no better than the average.

We wish to contribute to this problem data secured at the college student level, and may briefly present results for freshmen, sophomore, and junior classes of the University of Arkansas. These students constitute a fair sampling of the college students in the state. Our report gives results on 230 individuals. The music data we secured by giving the Seashore tests in the regular manner prescribed by the Seashore Manual. The intelligence quotients were obtained by the use of the Otis Self-Administering (higher examination) tests and the Army Alpha. The raw scores were converted into I.Q.'s by the method recommended by Otis in his directions for the tests. A large proportion of the subjects were given two or three of the intelligence tests. The results were found to agree practically as well as form A and B of the same test.

In Table I the distribution frequencies for the scores on intelligence and the six music tests are shown. For intelligence the

range is from 70 to 134 I.Q. Four people fall in the position 130–134. The mode is at 105–109, but there are almost as many in the station above and in the station below. The median I.Q.

TABLE I. *Distribution frequencies for the scores in intelligence, and for pitch, intensity, time, consonance, tonal memory and rhythm discrimination.*

I.Q. range	No. of subjects	Score range for music tests	Number of subjects falling at different range levels					
			Pitch	Intensity	Time	Con-sonance	Tonal memory	Rhythm
130–134	4	95–99	2	5	1		4	
125–129	10	90–94	5	60	6	1	19	18
120–124	18	85–89	19	74	25		16	28
115–119	32	80–84	41	45	54	22	20	42
110–114	34	75–79	34	25	60	24	21	32
105–109	36	70–74	31	10	44	74	36	65
100–104	33	65–69	10	2	22	53	26	21
95– 99	26	60–64	18	2	10	40	29	16
90– 94	17	55–59	18	2	4	14	12	3
85– 89	11	50–54	20	2	3	14	26	3
80– 84	6	45–49	17	2		1	11	1
75– 79	2	40–44	9		2	1	9	
70– 74	1	35–39	4				2	
		30–34	2	1				
Total	230							

for the 230 college students is 107.3. The same score range applies for all of the six music tests. This range extends from 30–99 and must be interpreted in terms of the description found in the instruction manual. For Pitch the greatest number of frequencies falls at 80–84, where we find 41 cases. This constitutes a fairly conspicuous mode. Seashore's results gave the mode at 85. The mode for Intensity is at 85–89, 74 cases, which is to be compared with the similar results of Seashore, which show the mode at 90. For Time the mode is not so conspicuous, there being 60 cases which fall between 75–79, while the corresponding value from Seashore's results is 80. For Consonance there is an outstanding high point, 74 cases, at 70–74, and we find that Seashore's value is 70. Four people touched the top of the scale in Tonal Memory, and the distribution is quite broad. However, there is apparently a real mode, 36 cases, at level 70–74. This differs quite a little from the mode, 80, as given by Seashore. Finally, in the test for Rhythm the largest number of cases, 65,

is found at 70–74, and the next largest group, 42, at 80–84, and the corresponding score given by Seashore is 75. From this comparison it will be seen that our distributions are fairly regular and that the characteristic values correspond quite closely with those that have been found with the much larger material measured by Professor Seashore. In one test only, that of consonance, the scores made at Arkansas exceed the Seashore mode.

The coefficients of correlation between the intelligence scores made by Arkansas students and the scores of the same students on the Seashore tests of musical talent are given in Table II.

TABLE II. *Correlation coefficients found for the intelligence scores and the Seashore music test scores on a group of 230 college students.*

	Coefficient	P. E.	Seashore's estimate
Pitch with I.Q.....	.32	.039	Cannot be taken as a test of intelligence.
Intensity and I.Q.....	.01	.045	Not closely correlated.
Time and I.Q.....	.13	.043	Varies slightly with intelligence.
Consonance and I.Q.....	.09	.044	Requires a certain degree of general intelligence.
Tonal memory and I.Q...	.10	.044	No estimate given.
Rhythm and I.Q.....	.12	.043	A measure of vividness and precision, not of general intelligence.

The highest, .32 ± .039, is between Pitch and I.Q. Smith (1) obtained for boys .70 ± .023 and for girls .63 ± .026 between general intelligence and pitch discrimination. We may agree, then, with Seashore and Mount (4) that general intelligence favors the securing of a good record, especially in the first test. This is quite different from holding that general intelligence positively correlates with psychophysic capacity. Taken as a group, our correlation results seem to confirm the position of Seashore that the music tests are not in any significant way tests of intelligence. To use Seashore's words, it is therefore "possible for a person, strong in other capacities, but with relatively low intellectual powers, to assume fairly important rôles in music within restricted areas or fields of music activity, but the great musician is always a person of great intellect."

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THE AESTHETIC ATTITUDE IN MUSIC

BY

MAX SCHOEN

This paper undertakes to present a summary of the most significant and reliable literature, theoretical and experimental, on the types of attitudes towards music, and to establish the relative value of these attitudes as aesthetic experiences. The criterion or basis for evaluation will be sought, as in the case of the attitudes, in the theoretical and experimental literature on the subject.

I

It is a fact of common everyday observation that individuals vary to a significant degree in what music means to them, and in what they get out of it.(1) Pages might be filled with quotations from the best and most cultivated minds in illustration of two extreme responses, as well as the gradations between them, from that of Dr. Johnson to whom music was the "costliest of rackets," to Carlyle to whom it represented "a kind of inarticulate, unfathomable speech which leads us to the edge of the infinite, and lets us for moments gaze into that." To Romain Rolland music is a "moony light to eyes wearied of the harsh brilliance of this world's sun," while Charles Lamb sat through opera and oratorio, "till, for sheer pain, and inexplicable anguish, I have rushed out into the noisiest places of the crowded street, to solace myself with sounds, which I was not obliged to follow, and get rid of the distracting torment of endless, fruitless, barren attention." Of the few attempts made up to date to marshal these individual variations into types or classes, the outstanding contributions are those of Gurney, Hanslick, Ortman, Myers, and Lee.

Gurney (2) recognized two types of listeners, which "though they shade into one another, and may each of them in various

degrees be realized by a single individual in listening to a single composition, are for all that in their typical state radically different." The two types of listeners are the *definite* and the *indefinite,* the difference between the two lying in what it is they hear, and the kind of pleasure they experience. In definite hearing there is a perception of form, namely, melodic and harmonic sequences and combinations, while indefinite hearing involves "merely the perception of successions of agreeable-toned and harmonious sound." This distinction is basic, since for Gurney, the outstanding feature of a melody is an "ideal motion," a melody consisting of units of motion, in which each tone "yearns" to move to another tone and each unit of motion or phrase to another unit, and both movements tending towards a definite position. These motions, one vertical as pitch, and the other horizontal as rhythm, give each melody a unity of form and a definiteness which constitute its unique individuality. The indefinite listener, therefore, who does not grasp the form, does not hear music at all, but only discreet pleasant sounds. It is the response to the "ideal motion" which is to Gurney the one essential source of the pleasurable experience of music, and which constitutes the aesthetic element of the art of tone. Consequently there are various reasons why "the pleasure arising from any series or combinations of sounds which conveys no distinct musical meaning should be lower and less than that attainable through more definite apprehension, . . . first, there is the evidence of the majority of those who at all enjoy listening to music, and who have experienced at different times both sorts of pleasure. Next, we have the right to identify the higher pleasure with the more specialized, that which is appreciated by the more developed and differentiated sense; and which of course belongs to the distinct exercise of the musical faculty, as opposed to the nearly universal susceptibility to the effect of rich and powerful sound. Next, while the impression of mere beauty of sound-color is exceptionally sensuous and passive, not admitting of any of the indirect aesthetic effects given (as we have seen) by the material of architecture, nor of the associations of space and freedom which a painter's most formless hues may gain from the blue sky and

the other colored spaces of nature, the apprehension of musical motives, on the other hand, constitutes a specially active kind of self-realization. And lastly, there is the point already sufficiently insisted on, the power of, in some measure at least, permanently possessing forms which have once become familiar, in contrast to the utter transience of all formless sound-effects."

A classification similar to that of Gurney is made by Ortman,(3) who labels Gurney's indefinite hearer as the *sensorial* type and the definite listener as the *perceptual* type. The *sensorial* type Ortman calls the most rudimentary form of response, which has for its basis the raw sensory material of music. "Responses of the sensorial type are limited entirely to what is given in the auditory stimulus itself; and this stimulus is restricted here to a single tone, or an unanalyzed chord. The characteristics of such a stimulus are, in audition, pitch, intensity, duration, quality, and whatever sensorial factor we find, must be explained as the result of the effects of these characteristics." The *perceptual* type Ortman describes as the interpretation of the sensorial reaction. "The perceptual response is concerned with auditory things; progressions, sequences, motive, phrase, form, outline, contrast, ascent, descent, movement, and many others. The basic difference between the perceptual and sensorial responses is the presence in the former, and the absence in the latter, of relationships. The sensorial response represents a single impression upon consciousness. In the perceptual the effect of each separate stimulus is determined by its environment. What has preceded the present stimulus leaves its influence upon it. A tone now becomes a part of a melody, a chord becomes a part of a tonality, and a phrase becomes part of a form." On the mental side, the perceptual response involves active or voluntary attention. "Since perception is a conscious process demanding for its proper operation both analysis and synthesis, it is accompanied by active or voluntary attention. It means a response to the stimulus different from the nature of the stimulus itself. This added increment is the result of sustained concentration or mental work." Ortman recognizes a third type, an *imaginal,* which, however, fits perfectly with Gurney's definite response, since its basis is the "ideal

motion," namely, a feeling for tonality, anticipated chordal resolutions, responses to a melody *in harmony,* and the like.

A somewhat different grouping is made by Hanslick,(4) whose essay is devoted to combating the popular notion that the aim and object of music is the expression of emotion. By inference from his argument Hanslick would recognize two types of listeners, the impure or the extrinsic, and the pure or the intrinsic. To the extrinsic listener " sound and its ingenious combination are but the material and the medium of expression, by which the composer represents love, courage, piety and delight. The innumerable varieties of emotion constitute the idea which, on being translated into sound, assumes the form of a musical composition." To such listener the substance of music is in that it implies: " the whispering of love, or the clamour of ardent combatants." For the intrinsic hearer, on the other hand, the essence of music is sound and motion, and it expresses nothing but musical ideas, that is, music consists wholly of sounds artistically combined. " The ingenious co-ordination of intrinsically pleasing sounds, their consonance and contrast, their flight and reapproach, their increasing and diminishing strength—this it is, which in free and unimpeded forms, presents itself to our mental vision."

Of experimental studies on types of listeners that of Myers (5) is probably the most exhaustive and inclusive that has as yet appeared. His classification is based upon introspective reports of fifteen persons of various degrees of musicalness who reported their reactions to six musical compositions played on the phonograph, namely: Beethoven's Overture to Egmont (op. 84), Tschaikowsky's Valse des Fleurs from the Casse Noisette Suite (op. 714), and his Italian Capriccio (op. 45), Mendelssohn's Overture to the Hebrides (Fingal's Cave, op. 26), the first of Grieg's Symphonic Dances (op. 64), and Kreisler's setting and rendition of Couperin's Audabe Provincale.

From his data Myers deduces the following four types of listeners:

1. The *intra-subjective* type. To this type of listener music appeals for the sensory, emotional, or conative experiences which

it arouses. That is, the attention of the hearer is held by the sensory effects, or the flow of feeling, or the experience of self-activity induced by the music.

2. The *associative* type. In this response the main appeal of the music lies in the extra-musical ideas and associations which it suggests. For instance, " I was in the Queen's Hall, a fair girl in a pink dress was playing and another girl was accompanying her. The violinist has a sad look about her. I felt she had a sorrow in her life."

3. The *objective* type. This listener assumes a critical attitude toward the music, it is analyzed and evaluated as an aesthetic structure. " I noticed by what simple means in these modern days he gets his effects. . . . I noticed also . . . how he gathered up his climax by syncopation."

4. The *character* type. Here the music is personified as a subject, given character traits such as morbid, joyful, dainty, mystic, reckless, playful, etc.

Vernon Lee's study on Varieties of Musical Experience (6) is more limited in its scope, in that the experimenter had specifically mentioned two possible types of attitudes towards music, and then asked the subjects to classify themselves into one or the other of the two groups.

Lee believes that " an inquiry into what music does in the mind of the hearer, or more correctly, of what the mind of the hearer does in response to the music which he hears " is an answer to the question of what music is. She therefore asked her subjects to respond to the following question: " When music interests you, has it got for you a meaning which seems beyond itself; or does it remain just music? "

She reports that " about half of the subjects interrogated did precisely answer that undoubtedly music had a meaning beyond itself, many adding that if it had not it would constitute only sensual enjoyment, and be unworthy of their consideration, some of them moreover indignantly taking in this sense my words about music remaining just music. That for these persons music did not remain just music, but became the bearer of messages, was further made certain by pages and pages, often of unex-

pectedly explicit or eloquent writing, which admitted to describe the nature of that message, to describe the things it dealt with and the more or less transcendental spheres whence that message of music seemed to come."

" So far for one-half of the answers. The other either explicitly denied or disregarded the existence of such a message; insisted that music had not necessarily any meaning beyond itself, and far from taking the words ' remains just music ' as derogatory to the art or to themselves, they answered either in the self-same words or by some paraphrase, that when they cared for music it remained just music. And in the same way that the believers in music as a message often gave about the contents of that message, so, on the other hand, the subjects denying the existence of a message frequently made it quite clear that for them the meaning of music was in the music itself, adding that when really interested in music they could think of nothing but the music."

Concerning the nature of the message or the meaning found in music by the first group of listeners, Lee comments as follows: " The affirmative answers, often covering many pages, showed that according to individual cases the ' message ' was principally of one of these kinds, visual or emotional, abstract or personal, but with many alterations and overlapping. But fragmentary, fluctuating, and elusive as it was often described as being, and only in rare cases defining itself as a coherent series of pictures, a dramatic sequence or intelligible story, the message was nevertheless always a message, in as much as it appeared to be an addition to the hearers' previous thoughts by the hearing of that music; and an addition due to that music and ceasing with its cessation." The other half of the listeners did not deny the existence of a meaning or a message in music, but nevertheless claimed that " whenever they found music completely satisfying, any other meaning, anything like visual images or emotional suggestions, was excluded or reduced to utter unimportance. Indeed this class answered by a great majority that so far as emotion was concerned, music awakened in them an emotion *sui generis,* occasionally shot with human joy or sadness, or on the whole analogous to the exaltation and tenderness and sense of

sublimity awakened by the beautiful in other parts or in nature, but not to be compared with the feeling resulting from the vicissitudes of real life. It was nearly always persons answering in this sense who explicitly acquiesced in the fact that music could remain, in no derogatory sense but quite the reverse, just music."

II

Principles of Evaluation

The first principle as a basis for evaluating the relative aesthetic significance of the various attitudes outlined above is borrowed here from William James. "It is a good rule in physiology," says James, "when we are studying the meaning of an organ, to ask after its most peculiar and characteristic sort of performance, and to seek its office in that one of its functions which no other organ can possibly exert. Surely the same maxim holds good in our present quest. The essence of religious experiences, the thing by which we finally must judge them, must be that element or quality in them which we can meet nowhere else, and such a quality will be of course most prominent and easy to notice in those religious experiences which are most one-sided, exaggerated and intense." In its bearing upon the present problem this principle suggests that the essence of the aesthetic experience in music, or for that matter, the aesthetic experience derived from any source whatever, must possess a quality of a unique nature, a quality that marks off this experience from other types of experiences such as the good, or true or useful. The experience of beauty is good, true, and useful, but the quality that stamps it as "beauty" is not its goodness, truth, or utility, since an experience may be all these, but not therefore beautiful.

Second, every experience derived from music cannot, by virtue of that fact alone, be an experience of beauty, for, if it were, then beauty would be anything and everything, and therefore nothing. When one exclaims, "This is beautiful" he must have experienced a quality which lead him to designate the object as beautiful instead of designating it by some other quality. Likewise, if several persons label an object as being beautiful they

must have experienced a common quality which led them to a common response.

Third, in a discussion of the nature of beauty the issue involved is not that concerning the *validity* of the different kinds of experiences that may be derived from a work of art, but of the relative significance of the experiences as experiences of beauty. Therefore, while all reactions to a work of art are equally *valid,* as experiences, for the person experiencing them, they are not of equal value as beauty simply because their stimulus is an art object. While it is true, then, that of tastes there is no disputing, it is equally true that of tastes there is evaluating, the basis for the evaluation being the essential nature of the experience under discussion, this essential nature lying in that unique quality which distinguishes that experience from other experiences.

III

The Experience of Beauty in Music

The essential nature of the aesthetic experience in music is to be sought, following the suggestion of James, in those cases in which it manifests itself in its most exaggerated, one-sided and intense form. The procedure for our search is thus evident: (1) an examination of what musicians and persons of outstanding musical taste such as Gurney and Hanslick, have to say about their musical experiences, (2) whether experimental studies on the subject support the conclusion drawn from (1).

1. Several years ago the writer sent out questionnaires and also had interviews with a number of prominent musical artists, with the object in view of obtaining from them a statement of their musical experiences. The questions put to these persons were as follows:

"When you find yourself in an attitude of intense musical appreciation, what is your general condition of being, physical and mental?"

The answers from a few of the persons to this question follow:

"I am usually in a state of muscular tension—with my hands clenched. If I am really in the aesthetic ecstasy, I am absolutely

oblivious of my surroundings. I cannot get to that point except by the piano—that is really the only instrument that can give me the genuine aesthetic feeling—then everything is black except where the piano is, and I am very tired afterwards. The effect stays with me for a day or two. I feel as though I do not want to be interrupted by anybody or anything rough or harsh, in any sense. I want nothing rough or coarse which could not share that state with me. . . . If I begin to think of any matters of personal interest or any memories while listening, then it is a sure sign that the music is mediocre, that it does not hold my attention as music. There are some associations in situations of this kind. If I hear some dance music, I may feel slightly different in mood, and I can sometimes trace it to a more or less temporary emotional experience, to some association with the dance. Even matters of momentary interest can have that influence upon the music that is not the musical experience at all. I might have the same experience with anything else. The smell of a perfume may have its associations. It is not an aesthetic one, but you can have a very definite association with some girl who has used that particular type of perfume. I have had experiences in which the music had a soothing effect, and I started day-dreaming, perhaps extravagantly, of power and mastery, perhaps I dream of doing something which reveals social approval. If I do that, it means that I do not care a rap about the music."

"When I am in a state of the most intense enjoyment of music, I am never introspective. I never catch myself at it. Looking back on it, I should say that I have rather become the music than remained something apart with some attitude toward it. On the less intense absorption, I should say that music in a very definite way restores me in body, mind, and spirit. I am afraid I am a poor informant though in this case, for I really cannot state confidently any one reaction except that of a wrapt condition, at the end of which I take a deep breath and come back. My enjoyment is derived directly from the music. Associations or imagery, even when suggested by the title, fade from my mind as I listen to the music, and I do little except get my mouth set for the particular kind of taste which I am about to receive."

"When I find myself in the act of intense enjoyment, it is generally after the experience is over. For such moments, loss of myself is fairly complete. This is, however, for special occasions; the ordinary rhythmic enjoyment of music is very much on the plane of any usual sensuous enjoyment, as eating or drinking. The self is perfectly conscious of the thing being enjoyed. In the supreme moment there seems to be a fusion and I am one with the thing heard. Such moments cannot be but a few seconds in duration, but they raise the whole attitude into a different level. . . . Music that does not affect me strongly often sets me off into a revery, if it does not roil me. But in the supreme moment the enjoyment seems to come directly as the result of the music, without any suggestion whatever, except that of motion and movement. What I seem to feel is perfection, the realization of an ideal, and perfect harmony between matter and spirit. Why this should move me so, I am unable to tell unless it may be that as in our ordinary consciousness our physical, mental, and spiritual limitations are constantly with us and we are living most of the time, because of our personality, in a state of strife, whenever a perfect moment comes and we forget ourselves, and find the strife giving place to a perfect union, we experience a certain vacation or respite from ourselves."

Hanslick is nothing short of combative in his insistence as to what a truly musical experience is. He writes "The task of clearly realizing music as a self-subsistent form of the beautiful, has hitherto presented unsurmountable difficulties to musical aesthetics, and the dictates of 'emotion' still haunt their domain in broad daylight. Beauty in music is still as much as ever viewed only in connection with its subjective impressions, and books, critiques, and conversations continually remind us that the *emotions* are the only aesthetic foundation of music, and that they alone are warranted in defining its scope." This proposition Hanslick claims to be entirely false. "The beautiful, strictly speaking, *aims at nothing,* since it is nothing but a form which, though available for many purposes according to its *nature* has, as such, no aim beyond itself. If the contemplation of something

beautiful arouses pleasurable feelings, this effect is distinct from the beautiful as such. I may, indeed, place a beautiful object before an observer, with the avowed purpose of giving him pleasure, but this purpose in no way affects the beauty of the object. The beautiful is and remains beautiful though it arouse no emotion whatever, and though there be no one to look at it. In other words, although the beautiful exists for the gratification of an observer, it is *independent* of him.

" In this sense music, too, has no *aim* (object) and the mere fact that this particular art is so closely bound up with our feelings, by no means justifies the assumption that its aesthetic principles depend on this union." What then constitutes the aesthetic response in music? In Hanslick's opinion " the art aims above all, at producing something beautiful which affects not our feelings but the organ of pure contemplation, our imagination."

" In the pure act of listening, we enjoy the music alone, and do not think of importing into it any extraneous matter. But the tendency to allow our feelings to be aroused, implies something extraneous to the music. An exclusive activity of the *intellect,* but a *logical* relation, while a predominant action on the feelings brings us on still more slippery ground, implying, as it does, a *pathological* relation."

The beautiful in music, Hanslick insists, is specifically musical. " By this we mean that the beautiful is not contingent upon, or in need of any subject introduced from without, but that it consists wholly of sounds artistically combined. The ingenious coordination of intrinsically pleasing sounds, their consonance and contrast, their flight and reapproach, their increasing and diminishing strength—this it is, which in free and unimpeded forms, presents itself to our mental vision." What is it then that music expresses? The answer is musical ideas. " Now, a musical idea, reproduced in its entirety, is not only an object of intrinsic beauty, but also an end in itself, and not a means for representing feelings and thoughts. The essence of music is sound and motion.

" It is extremely difficult to define this self-subsistent and specifically musical beauty. As music has no prototype in nature, and expresses no definite conceptions, we are compelled to speak of it either in dry, technical terms, or in the language of poetic

fiction. Its kingdom is, indeed, 'not of this world.' All the fantastic descriptions, characterizations, and periphrases are either metaphorical or false. What in any other art is still descriptive, is in music already figurative. Of music it is impossible to form any but a musical conception, and it can be comprehended and enjoyed only in and for itself.

"The ideas which a composer expresses are mainly and primarily of a purely musical nature. His imagination conceives a definite and graceful melody aiming at nothing beyond itself. Every concrete phenomenon suggests the class to which it belongs, or some still wider conception in which the latter is included, and by continuing this process, the idea of the absolute is reached at last. This is true of musical phenomena. This melodious Adagio, for instance, softly dying away, suggests the ideas of gentleness and concord in the abstract. Our imaginative faculty, ever ready to establish relations between the conceptions of art and our sentiments may construe these softly-ebbing strains of music in a still loftier sense, *e.g.*, as the placid resignation of a mind at peace with itself, and they may arouse even a vague sense of everlasting rest."

When we turn to Gurney we find once more that he leaves no doubt as to what constitutes for him a truly musical experience. Gurney insists, as does Hanslick, that "expressiveness of the literal and tangible sort is either *absent or only slightly present* in an immense amount of impressive Music"; that to "suggest describable images, qualities, or feelings, known in connection with other experiences, however frequent a characteristic of music, makes up no inseparable or essential part of its function; and that this is not a matter of opinion, or of theory as to what should be, but of definite everyday fact." Furthermore, "when we come to the *expression* aspect of music, to the definite suggestion or portrayal of certain special and describable things, we should naturally expect to be able to trace in some degree the connection of any special suggestion or shade of character with some special point or points in the musical form and the process by which we follow it. . . . None of them . . . can be held accountable for any musical *beauty* which may be present; a tune is no more constituted beautiful by an expression, *e.g.*, of mourn-

fulness or of capriciousness than a face is. The impressiveness which we call beauty resides in the unique musical experience whose nature and history have just been summarized."

In the writings and expressions of personal experience presented above we find an insistence upon a unique attitude present in the truly musical experience the substance of which appears to be that in this experience everything that is not of the sum and substance of the music itself is ruled out of consciousness, and that nothing is present in the mind of the listener but an awareness of " the thing itself." Attention is completely focused upon and absorbed by the music itself to an extent that subject and object become merged one with the other. An excellent summary of what is involved in this experience is presented in Bell's doctrine of Significant Form, which, although its advocate insists is a new principle " by reference to which the respectability, though not the validity, of all aesthetic judgment can be tested," is in fact but a succinct statement of the core of all aesthetic theory, minus the trimmings of definitions that " has been groping its way towards recognition in the last few decades. It is the *liking of a thing for itself* in contrast to the valuing of a thing as a means towards something else. It has been variously called 'intrinsic,' 'independent,' 'primary,' value. It simply marks off the attitude opposite to the practical attitudes." Significant Form Mr. Bell defines as " arrangements and combinations that move us in a particular way " and this particular way consists in the fact that what is present to mind in the experience is nothing but consciousness of form *per se,* that is, the thing itself, or those of its properties without which it would not be what it is. An account given by Mr. Bell of his own musical reaction will make clear what he means by Significant Form and also demonstrate the identity of his point of view with that of Gurney and Hanslick. " I am not really musical. I do not understand music well. I find musical form exceedingly difficult to apprehend, and I am sure that the profounder subtleties of harmony and rhythm more often than not escape me. The form of a musical composition must be simple indeed if I am to grasp it honestly. My opinion about music is not worth having. Yet, sometimes, at a concert though my appreciation of the music is limited and humble, it is pure.

Sometimes, though I have a poor understanding, I have a clean palate. Consequently, when I am feeling bright and clear and intent, at the beginning of a concert for instance, when something that I can grasp is played, I get from music that pure aesthetic emotion that I get from visual art. It is less intense, and the rapture is evanescent; I understand music too ill for music to transport me far into the world of pure aesthetic ecstasy. But at moments I do appreciate music as pure musical form, as sounds combined according to the laws of a mysterious necessity, as pure art with a tremendous significance of its own and no relation whatever to the significance of life; and in those moments I lose myself in that infinitely sublime state of mind to which pure visual form transports me. How inferior is my normal state of mind at a concert. Tired or perplexed, I let slip my sense of form, my aesthetic emotion collapses, and I begin weaving into the harmonies, that I cannot grasp, the ideas of life. Incapable of feeling the austere emotions of art, I begin to read into the musical forms human emotions of terror and mystery, love and hate, and spend the minutes, pleasantly enough, in a world of turbid and inferior feeling. At such times, were the grossest piece of onomatopoeic representation—the song of a bird, the galloping of horses, the cries of children, or the laughing of demons—to be introduced into the symphony, I should not be offended. Very likely I should be pleased; they would afford new points of departure for new trains of romantic feeling or heroic thought. I know very well what has happened. I have been using art as a means to the emotions of life and reading into it the ideas of life. I have been cutting blocks with a razor. I have tumbled from the superb peaks of aesthetic exaltation to the snug foothills of warm humanity. It is a jolly country. No one need be ashamed of enjoying himself there. Only no one who has ever been on the heights can help feeling a little crest-fallen in the cozy valleys. And let no one imagine, because he has made merry in the warm tilth and quaint nooks of romance, that he can even guess at the austere and thrilling raptures of those who have climbed the cold, white peaks of art."

IV

Evidence From Experimental Studies

2. If, in keeping with our findings, we divide listeners into two general types, (1) the *intrinsic* or those who are engrossed in "the thing itself" and (2) the *extrinsic,* or those to whom music is a means towards an end, it is apparent that Ortman's *sensorial* type, Myer's *intra-subjective, character* and *associative* types, and Lee's "message" type belongs under (2), while the perceptual and imaginal types of Ortman, the objective type of Myers, and the "no message" type of Lee come closest to (1). What have these investigators to say about the musical value of the types as established by them?

The sensorial reaction, according to Ortman, is typical of children, untrained adults, untalented pupils, and is the predominant factor in popular music. Thus Ortman's findings support the conclusion of Gurney as to the musical significance of the sensorial-indefinite response. Of the perceptual and imaginal types in which attention to structural form, or the substance of music as music, is predominant, Ortman says: "The perceptual response in all but a very primitive form, is largely absent from the response form of the untalented person. This type of response is preeminently that of the talented person. . . . We may expect to find the auditory imaginal response characteristic essentially of trained musicians and superiorly talented laymen who have frequent associations with auditory stimuli." Again it is apparent that Ortman's findings support both Gurney and Hanslick.

For the musical significance of the types established by him, Myers concludes that the objective attitudes towards music "in which the musical material is considered in reference to the listener's standard, occurs most frequently among those technically trained in music, who tend to adopt a critical attitude and are interested in the material of their art." This type of listener has a tendency to suppress all personal feelings, activities, associations, and characterizations that the music might evoke in favor of the critical, analytical standpoint. As to the place of associations or imagery in the musical responses, Myers claims that

" in the grossly unmusical, music evokes no associations, because it evokes no corresponding emotion. In the professional musician, music also evokes few or no associations, because he tends to inhibit them by his assumption of a critical, objective attitude. Among the most highly musical associations tend also to be repressed, because the music comes to be listened to for its own meaning and beauty, apart from the meaning and beauty derived from associations. In four of the five persons whose temperament was extremely artistic but who had little or no technical knowledge of music, associations were to a large extent replaced by symbols, *e.g.*, of pattern, color, or expanse, the activities of which, however, tended themselves to evoke associations."

" When the average person listens to music, then, associations are enjoyed for their own sake, adding enormously to the total aesthetic appreciation obtainable. The associations may be in themselves beautiful; they invite the listener to share in the beauty of a story and in the emotions of the persons created in his imagination. Among the more highly musical I find that associations are more particularly apt to intrude when the music is felt to be ' stagey,' unreal, meretricious, or vulgar. Thus M. reports associations as the music ' began to get more barbaric ' and as he ' lost interest in the music.' He observes, however, ' The middle of the second movement (which he enjoyed) switched me off my imagery, and I returned to the pure consideration of the music.' "

" It is by no means strange that associations should appear among the highly musical when music lacks interest or inherent beauty, whereas the less musical tend to appreciate music not so much on the grounds of its inherent beauty as for the enjoyment of the associations evoked. The explanation depends on difference of aesthetic level, the level of the musically gifted person standing higher than that of one averagely musical. So long as the former attending merely to the music, *qua* music, can maintain his high level of aesthetic enjoyment, associations are debarred from consciousness. But when for any reason he fails to maintain that level, *e.g.*, because his aesthetic appreciation ceases, then the products of lower-level aspects enter, *e.g.*, associations more or less incongruous with the enjoyment of beauty."

The intra-subjective aspect Myers puts down as the lowest kind of beauty since in this attitude the person surrenders himself to the sensory, emotional, and impulsive effects of the music. In this case "as the listener gives himself up to the enjoyment of such experiences, all that he gets is delight or joy, not beauty. As Bullough rightly points out, a process of psychical 'distancing' is required in order that any of his sensations or emotions may appear beautiful. One must look on them with a certain detachment, to a certain extent impersonally. He has to project the beauty into his sensory, emotional or conative experience, instead of subjectively appreciating the delight or joy to which they give rise. He has to look on them as a spectator, and in some measure at least to regard that experience as constituting in and for itself a living, unitary, independent entity."

Myers summarizes his general conclusions from his studies as follows: "We can now see how the various aspects which we have distinguished in the listener may each play a part in the awareness of beauty, and how the different fundamental connections of music, with courtship, with dancing, and rudimentary language, may each contribute to aesthetic enjoyment. These different connections may be differently stressed in different persons today, so that one tends specially to sexual, another to dramatic, another to verbal associations with music. But we come to recognize that, apart from these connections, music may be appreciated for its own inherent beauty, that is to say, apart from its sensuous, emotional or conative influences and from associations, symbols and products of "animistic" characterizations. The one common and essential attitude required for aesthetic enjoyment is one of detachment. The listener must view the music, as Bullough rightly insists, from a certain psychical 'distance.' If that distance be excessive as occurs in listening for the first time to exotic music or to other unfamiliar styles of music, the person feels too remote to get, as it were, to grips with the art material. It is overdistanced. On the other hand, it is underdistanced, when he surrenders himself wholly to its influence in such a way that he is a more or less passive instrument, played upon by the music, without paying any regard to

his sensations, images, emotions, or impulses, save in so far as they have immediately personal and 'practical' import."

Of her two types of listeners, the one to whom music was just music, and the other to whom the significance of music lay in the message that is conveyed, Lee finds that "the more musical answerers were also those who repudiated the message, who insisted that music had a meaning in itself, in fact, that it remained for them 'just music.' A certain number of highly musical subjects not only declared this to be the case with themselves, but foretold that we should find it so with every sufficiently musical hearer. Their own experience was that the maximum interest and maximum pleasure connected with music can leave no room for anything else. And this answer leads to the framing of queries bearing upon musical attention; queries which elicited some very unexpected information. For the distinctly musical attention was liable to fluctuations and lapses. They were continually catching themselves thinking of something else while hearing music. They complained of their own inattention and devagation. But—and this is the important point in the evidence—these lapses were regarded by them as irrelevancies and interruptions; the music was going on, but their attention was not following it. The less musical hearers, those also who found in music a meaning beyond itself, seemed comparatively unaware of such lapses or interruptions. From some of their answers one might have gathered that no musical person could sit through two hours of a concert with unflagging enjoyment. But further sets of inquiries revealed that although unbroken by boredom, restlessness or the conscious intrusion of irrelevant matters, that enjoyment was not confined to the music. When asked whether the music suggested anything, they abounded in accounts of inner visions, trains of thought and all manner of emotional dramas, often most detailed and extensive, which filled their minds while, as they averred, they were listening to the music; indeed some of which, they did not hesitate to admit, constituted the chief attraction of the music."

Lee finally concludes that there exist two different modes of response to music, namely, "*listening* to music, the other *hearing* music with lapses into merely overhearing it. Listening implied

the most active attention moving along every detail of composition and performance, taking in all the relations of sequences and combinations of sounds as regards pitch, intervals, modulations, rhythms, and intensities, holding them in the memory and co-ordinating them in a series of complex wholes, similar (this was an occasional illustration) to that constituted by all the parts, large or small, of a piece of architecture; and these architecturally co-ordinated groups of sound-relations, *i.e.*, these audible shapes made up of intervals, rhythms, harmonies and accents, themselves constitute the meaning of music to this class of listeners; the meaning in the sense not of a message different from whatever conveyed it, but in the sense of an interest, an importance, residing in the music and inseparable from it."

" Hearing music, on the other hand, as it is revealed by our answerers is not simply a lesser degree of the same mental activity, but one whose comparative poverty from the musical side is eked out and compensated by other elements. The answers to our questionnaires show that even the least attentive hearers have moments, whose frequency and number depend both on general musical habits and on the familiarity of the particular piece or style of music, of active listening; for they constantly allude to their ability to follow or grasp, as they express it, the whole or only part of what they happen to hear. But instead of constituting the whole bulk of their music experience (in such a way with any other that is recognized as irrelevant) these moments of concentrated and active attention of the musical shapes are like islands continually washed over by a shallow tide of other thoughts, memories, associations, suggestions, visual images and emotional states, ebbing and flowing around the more or less clearly emergent musical perceptions, in such a way that each participates on the call of the other, till they coalesce and into the blend of musical thoughts there enters nothing which the hearer can recognize as inattention, as the concentrated musical listener recognizes the lapses and devagations of which he complains."

V

The answer to the question as to what constitutes the aesthetic attitude in music stands out clearly and insistently. The beautiful in music lies in " listening to music," and not in " hearing music " ;

not in the associations, images, reflections, emotions, that it may arouse, as secondary or derived effects, but in the experiencing of the "thing itself," the musical form. And even this experiencing of the "thing itself" must be direct, spontaneous, detached, and not arbitrary, critical or analytical. That is, it must be "listening *to* music" not "listening *about* music." Myers rightly insists that "to treat the art material as a mere inanimate object having a certain value in reference to the person's standard is, . . . merely a last resource in the case of the untrained; while in the case of the technician, it is a consequence of his absorption in the material. It is the refuge of the untrained in the absence of the potentially aesthetic aspects of character, associations, and intra-subjective experience. It is the resource of the artist, in his endeavor by repression to escape from the influence of the other aspects, in order, it may be, to obtain the highest appreciable beauty of music, the beauty of musical meaning which is inexpressible in any other terms." The conscious critical attitude is destructive of the aesthetic experience, since a process of analysis destroys the very substance of the object that is being analyzed.

It may be appropriate here, in view of the conclusion drawn as to the nature of the beautiful in music, to close this study with a discussion of the reasons why, both by direct claim and indirect intimation, music has been called the measure of all the arts.

Why is music the measure of the arts? In what way, more than any of the other arts, is its material most susceptible to the creation of the experience of beauty?

In the first place, since the material of music is in itself most abstract, it lends itself to abstract form and is least liable to suggest anything beyond itself, or in other words, it most easily induces the condition of mental detachment. A tone is the most abstract of all the material of the arts, is least liable to suggest connections or relationships or meanings outside of itself. A tone is just a tone, whether high or low, smooth or rough, whereas even a color which is probably the most abstract, next to a tone, can carry with it very often a suggestion of an object of which it is an attribute. The very being of a tone is an end in itself,

free of complications or implications that lie outside of its own essence.

The same is true of a combination of tones into a melody. The logical sequence of tones is just a melody, never anything more than a melody, unless something is imposed upon it by the mind. A melody, "makes no assertion; so its claims on our admiration can have nothing to do with the 'True.' It serves no purpose; so it raises no question as to the aesthetic worth of imitation and the proper relation of art to nature are problems which it never even suggests. From the endless controversies about Realism, Idealism, and Impressionism, with which the criticism of other arts have been encumbered, musical criticism is thus happily free; while the immense changes which have revolutionized both the artistic methods and the material resources of the musician—changes without a parallel either in literature, in painting, in sculpture, or even in architecture—have hindered the growth of an orthodox tradition. Music thus occupies in some respects a place apart; but its theoretic importance cannot on that account, be ignored. On the contrary, it becomes all the more imperative to remember that no aesthetic principle which fails to apply to it can be other than partial and provincial. It can never claim to be a law governing the whole empire of aesthetic beauty."

In the second place, a material that is abstract can at its utmost embody but an abstract content. From all experimental evidence on the effects of music, the conclusion stands out that this effect is always of the nature of a mood but never an emotion. Thus, music may create a condition of sublimity, sadness, gayety, but never produces anger, jealousy or fear. Even the most programatic of program music results most often in a general feeling rather than an emotion. Thus, even in its content, if one may speak of the content of music aside from its form, music creates a condition of affective detachment and is least liable to give reactions of life in the form of emotions. It is probably for this reason that Schopenhauer goes directly to music when in search of the best and most complete avenue for the escape from life.

In the third place, music is the measure of the arts because it

satisfies in the largest degree the principle of unity of matter and material. In the words of Walter Pater's "Renaissance" "For while in all other kinds of art it is possible to distinguish the matter from the form, and the understanding can always make this distinction, yet it is the constant effort of art to obliterate it. That the mere matter of a poem, for instance, its subject, namely, its given incidents or situation—that the mere matter of a picture, the actual circumstances of an event, the actual topography of a landscape—should be nothing without the form, the spirit, of the handling, that this form, this mode of handling, should become an end in itself, should penetrate every part of the matter; this is what all art constantly strives after, and achieves in different degrees."

Where form and content are separable, the content is always concrete and definite, and the more concrete and definite the content the closer it is to life, the closer to life it is the more meaning it has, and the more meaning it has the further is it removed from mental and affective detachment. In a melody the content is the form and the form is the content, and any separation of the two is always the result of forcing something in the mind of the auditor upon the music, rather than a resemblance of the music to anything outside of itself. Thus, we find that in music the ideal conditions for beauty as a self-sufficient, complete in itself, intrinsic experience, are most completely met. Even the history of music bears evidence of the purity of music as pure, formal beauty, free of any entangling alliances with anything not of its intrinsic qualities, since we find that program music, which attempts to go beyond itself and paint pictures or tell a story, has always been looked upon as a low form of musical art, while the opera is still hardly entirely admitted into the sacred precincts of the hall of tonal art.

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A MEASURE OF ART TALENT

By Norman C. Meier

While the measurement of talent-complexes in the musical field has attained considerable refinement through the reasearch of Seashore and his co-workers,[1] the student of graphic art has been offered no similar technique designed to point out the probabilities of success or non-success. Construction of a test device for the embryo artist is a difficult undertaking, and unless its claims be modest and justified would be apt to provoke resistance from a science-disdaining art world. But if a careful program of analysis and experimentation in which scientific and artistic factors are both given recognition precedes test development, the project should prove attainable and reasonable. These considerations have been discussed in a previous article (16) : it is the aim here to present the underlying theoretical aspects and present status of a technique developed in the Iowa Laboratory over the past six years and now nearing completion.[2]

The problem has been approached from various angles by Ayer,(1) Christensen and Karwoski,(4) Fischlovitz,(6) Kline and Carey,(11) Manuel,(14) Paulsson,(19) Pintner and Toops,(20) Thorndike,(23) and Whitford.(24) In general one of three methods has been followed: the method of testing specific abilities, the method of selection, or the method of production. For a description and discussion of these methods the reader is referred to a publication of the writer (15) which also presents the results of preliminary experimentation and the reasons for preferring the method of selection.

In his technique, the measure of one's possibilities for success

[1] See Vols. VIII, IX and X, Iowa Studies, in the *Psychological Monographs.*

[2] With the coöperation of Dean Seashore, staff members in psychology and art, and with the aid of a grant from the Carnegie Corporation. To those participating in the Princeton Art Conference, at which this project was represented by Dean Seashore, the writer feels indebted for suggestions.

in graphic art is taken as being closely correlated with the degree of *aesthetic sensitivity.* In the entire heirarchy of qualities and abilities making up the art talent complex this one variable is regarded as best suited to laboratory treatment and as crucial in prognostic value. Specifically it is the ability to recognize compositional excellence in representative art-situations, or the ability to "sense" quality (beauty?) in an aesthetic organization. It is the ability which the artists manifest, to arrange, to re-arrange, and to select, the arrangement superior in organization; also to know when a composition has in it too much or too little, when the light and shade relations are correct, and when its elements are in conformity with the principles of aesthetic structure. Composition, which is significant in such widely divergent media and techniques as etchings, line drawings, sculpture, and portraiture, is hence placed above other considerations commonly regarded as significant in art talent.

This view is not blind to the merits of good color sense, artistic or imaginal resourcefulness, sense or perspective, or any one of twenty or more traits of the artist personality. It merely holds that certain of them are necessary or desirable, but that none is so *indispensable and important for ultimate success,* as composition.[3] Support of this view is found in the methods of great masters, who (with few exceptions) followed the practice of making trial-compositions (studies, blocking out diagrams, lay-outs), and from these selected the one judged best in organization. These studies have been preserved in great numbers, amounting to ten or more to a single production, and varying in size from small pencil sketches to the six-foot outlines of Constable. They, more than color, more than subject-matter, distinguish the master. On this point, it is assumed, the hopeful aspirant will diverge from the hopeless: the former will more readily detect the shortcomings of his drawings, while the artistically-deficient individual will always be uncertain in his efforts to distinguish between the good and the indifferent. We have this ability trait in evidence, furthermore, in the situation of the artist painting from nature, which

[3] Cf. Barnes (*2*), Bowie (*3*), Dow (*5*), Goldstein (*7*), Manuel (*14*), Neuhaus (*17, 18*), Langfeld (*12*), and Ross (*21*).

necessitates more or less walking about, seeking always a better vantage point from which the desired arrangement of trees, water, topography, and sky may be observed. Or, in still life, through this ability he will know whether he has too much in it or too little, or what should be added and what omitted; or given a certain outline and certain points, tones and relationships, he will know how to place them so they may appear connected harmoniously.

These working principles, appearing in all good art, usually go by the names of harmony, balance, and rhythm, with their variations, stability, symmetry, proportion, and unity. That good art may be objectively treated by conformity with such principles and that conformity with art principles leads to results far more certain to have universal appeal will probably not be seriously disputed.[4] The names are of less consequence than the fact of their reality.[5] The underlying sanction is found in the common experience of mankind which has found balanced arrangements—for instance, as they appear in nature (stability in mountains, symmetry in trees, etc.), or harmony in coloring (landscape, flower elements, the butterfly, etc.)—far more pleasing than disorder. But granted that man has genetically been in contact with the objective *basis* of these principles it is not known with any certainty how the response-sets become developed in the child. In a comprehensive investigation Goodenough (**8**) shows that the early years are characterized by a slow conceptual development and the drawing skill is but little in evidence during these years. There are probably no child prodigies in the art world similar to those in the music world (**8**, pp. 52–53) and in the few instances on record it is entirely probable that the showing may be accounted for by superior powers (special habits) of analytic observation coupled with forced training. Even those children without train-

[4] The tendency frequently met with among artists to minimize adherence to principles of aesthetic structure may be attributed to a confusion of *principles* with a connotation of mechanically perfect rigidity, and to the difficulty of recognizing habits of work which are no longer consciously studied but now performed with facility.

[5] A movement is under way to standardize the terminology and give definite meaning to principles. *Committee on Terminology* of the Federated Art Council, W. G. Whitford, Univ. of Chicago, Chairman.

ing, studied for the emergence of special ability, have, when exposed to training, soon equalized the difference (Rouma, 22). Goodenough, Kerschensteiner,(9) Kik,(10), and Manuel (14) all agree that intelligence conditions the rate of progress in the conceptual basis of art development, while Manuel holds that there is little correlation between intelligence and *drawing* ability, and Kerschensteiner and Kik have evidence that creative art is conditioned by mental factors but in copyist phases the higher skill may be possessed by the lesser intelligent. Kerschensteiner finds that the feebleminded never seem to attain coherence (unity—*zusammenhangenlosigkeit*). With the limited data at our disposal it appears not unlikely, however, that the aesthetic sensitivity of the individual develops slowly under fostering influences somewhat *in accordance with* the excellence or poorness of the child's sensory equipment. Hence it does follow that a child taken to all the great art museums of the world will then have a high degree of aesthetic responsiveness. There must, of course, be *integration.* The aesthetic attitudes or response-sets cannot be brought to a present high state of effectiveness until the child has been through a long-continued series of experiences wherein he has been confronted by an unlimited number of balance-situations, likewise innumerable unified organizations, as well as those in unbalance and those in disunity. The assumption is that the individual, meeting with and responding *adequately* to a preponderance of situations of good aesthetic merit, will have developed in the process a higher degree of aesthetic sensitivity than if the preponderance had been in the other direction.

Whatever the genesis is eventually found to be, the fact of variability in mature years is a matter of common observation substantiated by several investigations.(1, 4, 15) The foregoing consideration would indicate that a reliable measure of art talent should not be applied to age levels much under the eighth grade. The matter of vocational selection for the higher callings becomes acute in the later years of high school or early college, and a good technique would need to consider the typical perceptual and conceptual background of the high school senior or college freshman.

The method of sampling this talent-variable follows the method of selection. An effort is made to duplicate as nearly as possible the typical situations which confront the artist at work. It cannot well be required of the subject to lay out a number of trial-compositions and then to select the best. Differences of opinion would at once arise as to the criterion of best. The plan of having the trial compositions made in advance and simply requiring the subject to choose would probably be just as effective in sampling his judgment, provided the criterion of " correctness " was acceptable. In the test as developed, works of reputable artists were taken as the basis of rightness and were chosen always for their excellence in embodying some definite art principle; the other versions were modifications designed to alter the organization so as to produce varying degrees of aesthetic value. In this way a large number of problem-situations may be sampled in a short time, covering most of those ordinarily met with in the experience of the artist.

This technique, the controlled alteration process, was developed at first by taking some recognized work of art (*e.g.,* Del Sarto's *Madonna of the Harpies*), making an ink outline sketch, then constructing nine variations in an order of decreasing excellence, in this case by a progressive alteration of the spaces between the figures. Under actual test conditions the ten-variation presentation, following a modified paired comparisons order, was found too difficult because the difference between any two was slight. The variations were then reduced to five and in some cases exaggerated, with better results. Further experimentation, however, revealed that while the five-variation is apparently more duplicative of the mental procedure of the artist in making a selection from a number of sketches and also tends to reduce the chance factor, the two-variation plan seemed superior. The latter provides greater simplicity, less monotony, and involves a lesser degree of fatigue. It should be noted also that in the five-variation plan there is an elimination first of the one considered the worst, then the next, the next, until it has resolved itself into a contest between the last two.

The laboratory or experimental form of the test contained 50

two-variation items (pairs of pictures reduced photographically to a standard size) and 10 five-variation items. Results from administering the test to about 250 subjects in high school, college, and art classes demonstrated its selective range and indicated a validity that was encouraging, by five preliminary checks: (a) the general correspondence of individual scores with art experience or demonstrated art ability, (b) the normal distribution of scores in each class, (c) the success of individual test-items in diagnostic power, (d) the general non-correlation of scores with extraneous factors, as intelligence and (e) the fair reliability (.65) in uncorrected, ungraded, tentative form.

With the experience obtained in the laboratory form and through the aid of a grant of money the whole procedure was revised and refined. The two-variation presentation was adopted throughout; the test items were made larger; only one pair was mounted on a page instead of three; the number contemplated was raised to 175. A new survey was made for material and considerable further research was done in the manner of producing alterations. Ten artists on part time were secured and a better quality of work was maintained. The additional material canvassed included (a) works of the great masters, taken from black-and-white and color prints; (b) etchings, drypoints, mezzotints, and aquatints, from various sources; teaching drawings and studies; and illustrations from texts. The instruction sheet accompanying the test was remade with the aim of informing the subject of the alteration and nothing else, in order to economize time and assure more certainty in the basis for choice.

The greatest advance over the laboratory form has been in the technique of alteration. In practice this takes the form of changing some significant element in the composition which destroys or seriously affects the balance, unity, or other principles. The process is illustrated in Figure 1, in which the *Madonna of the Sack,* by Del Sarto, is considered as a theme possibility. The artist has laid out his figures in the form of two trangles. The larger one is placed nearer the middle point of the picture and nicely balances the smaller one placed farther away. If this were to be used as a test item the composition would be thus analyzed

into its structural elements, and an alteration then made to destroy the balance, retaining the original layout as correct, for comparison. Such a change could be effected by moving the larger triangle out, or the smaller triangle out, or by moving either one in.

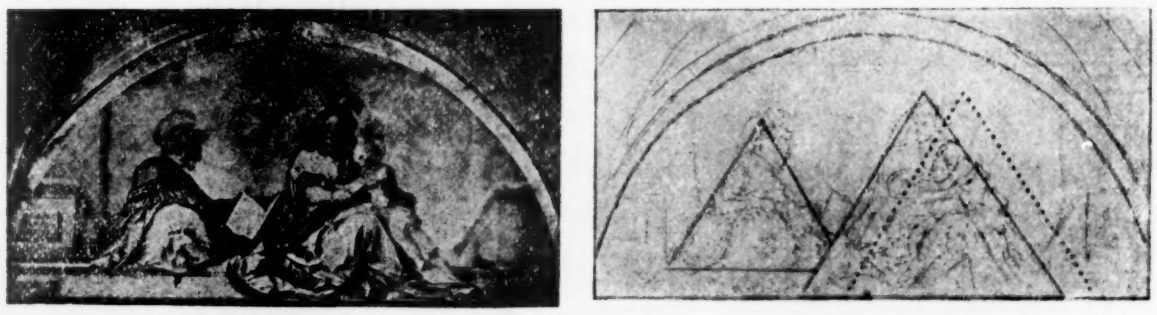

FIG. 1. Trial layouts for Madonna of the Sack by Del Sarto.

This subject lends itself perfectly to the process but is not desirable as a test item for the reason that it is too well known. The following bases of alteration have been used in constructing the Series II test items. The list is incomplete but representative of the method.

Presence or absence of some significant feature
Arrangement of principal object
Arrangement of some minor but significant object
Alternative completion details
Appropriateness or inappropriateness of some detail
Position of critical object with reference to other objects
Position of critical object with reference to picture as a whole
Suitability of background
Direction of suggested motion
Concentration or dispersion of foreground objects
Distribution of detail
Distribution of light patches
Concentration or dispersion of clouds
Location of the horizon line in the picture
Omission or inclusion of member in series
Exaggeration of member in rhythmic series
Agreement of outstanding detail with "atmosphere" of picture
Size relative to other objects
Use of angles versus curves in design of costume
Alteration of line of interest involving disturbance of symmetry or rhythm
Alteration of whole-and-part relations
Rearrangement of shadows
Quality of line
Change in anatomical detail
Postural changes through arm or base
Alteration of perspective

Figures 2 to 7 illustrate a few of the Series II test items. Figure 2 is a pen sketch adapted from Lemos in which unity

FIG. 2. Pen sketch adapted from Lemos.

FIG. 3. Adaptation from a Zorn etching. One significant detail has been changed.

and harmony are obtained in one version by subordination and grouping. (5) This represents a theme of slight difficulty which

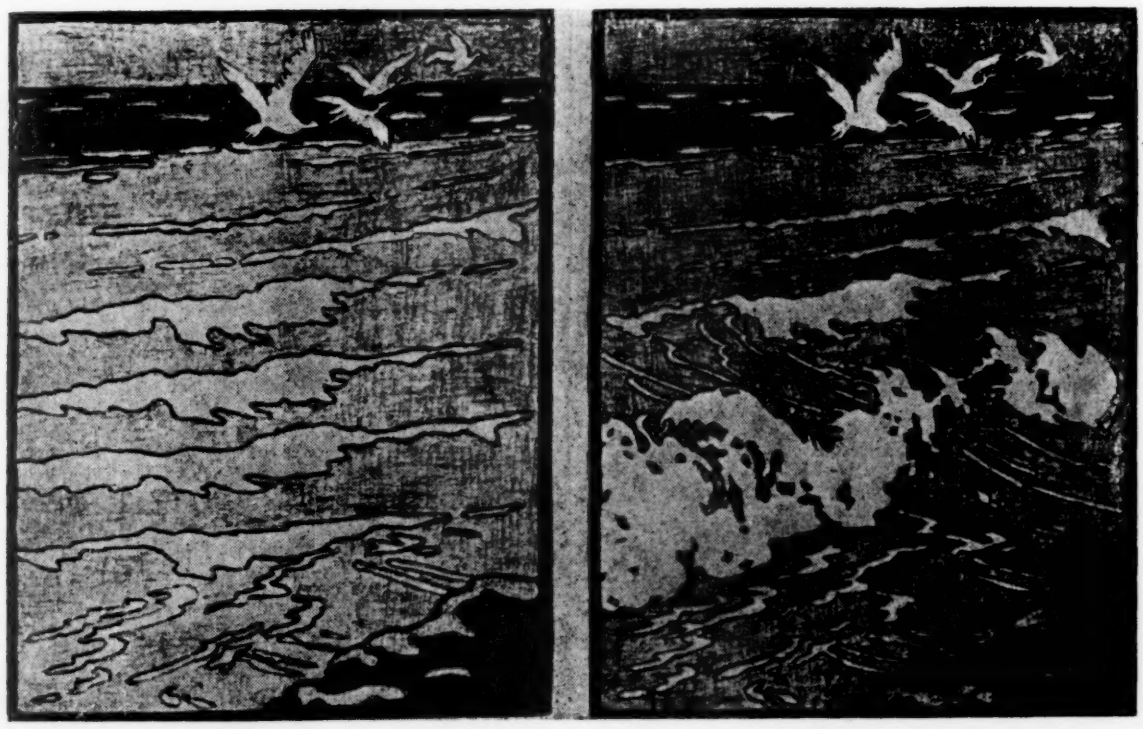

FIG. 4. Rhythmic order of waves in foreground.

FIG. 5. Background suitability.

few subjects having any prospects for art success at all should miss.

The problem in Fig. 3 is a more subtle one. In this adaptation

of a Zorn etching a single significant detail has been changed. This is a type of "alternative completion details." In forming a judgment the aesthetically sensitive will note the harmony or its absence between the apron and the remainder of the picture, as evidenced in (a) the character of line and general design, and (b) the relative light value for its location in the picture.

In Fig. 4, an example of the alteration of rhythmic order, the question concerns the character of the waves in foreground. In

FIG. 6. A slight change of a part seriously affects the stability.

this scene the rhythm of wave crest and trough, going through a rapidly decreasing magnitude away from the shore, is redesigned with results which the subject is called upon to judge.

Fig. 5 constitutes a good example of background suitability. The aim of the artist is to feature the girl, not the background. In one the attention is held to the girl's features; in the other the background design competes on equal or better terms.

With Fig. 6 a slight change of position of one arm seriously affects the stability (balance) of the principal figure. In one version the left arm grasping the book gives the sense of anchoring and providing security and restfulness in the picture; in the other there is a suggestion of a toppling column.

Fig. 7 is representative of the type of theme which may be stated as "agreement of some outstanding detail with the 'atmosphere' of the picture," in which the outstanding detail is the posture of the old man. Not only is the posture significant in itself, but in the correct version the line made by the head and back conforms with three other lines in the composition.

FIG. 7. Illustrating agreement of some prominent detail with the atmosphere of the picture.

These may be taken as fairly typical of the Series II test exhibits. The number finally completed and used, including a few from the preliminary form, was 183. These were arranged by chance order in four loose-leaf books. The test was recorded on a two-page printed blank providing for L-R judgments and giving a brief statement of the difference in each case between the two pictures. No time limit was imposed; the actual time usually required was from forty to ninety minutes. The number of items—183—was sufficiently large so that about one-third might be eliminated and a final form be constructed from the more desirable ones It was proposed then to administer the test to

1,000 subjects including three general classes: eighth grade, high school, and art students.

The new test was accordingly given to 1,081 subjects in grade schools, normal schools, colleges, and private art schools; in two cities of a half-million population each, one community of 50,000, two small cities of 8,000 and 15,000 respectively, and in one village. Of this number 386 were art majors and the other 695 were persons with no art training. The distribution of scores in these two groups is shown in Fig. 8.[6] For convenience in statistical treatment the subjects were divided into five groups: eighth grade, tenth grade, twelfth grade, art students,

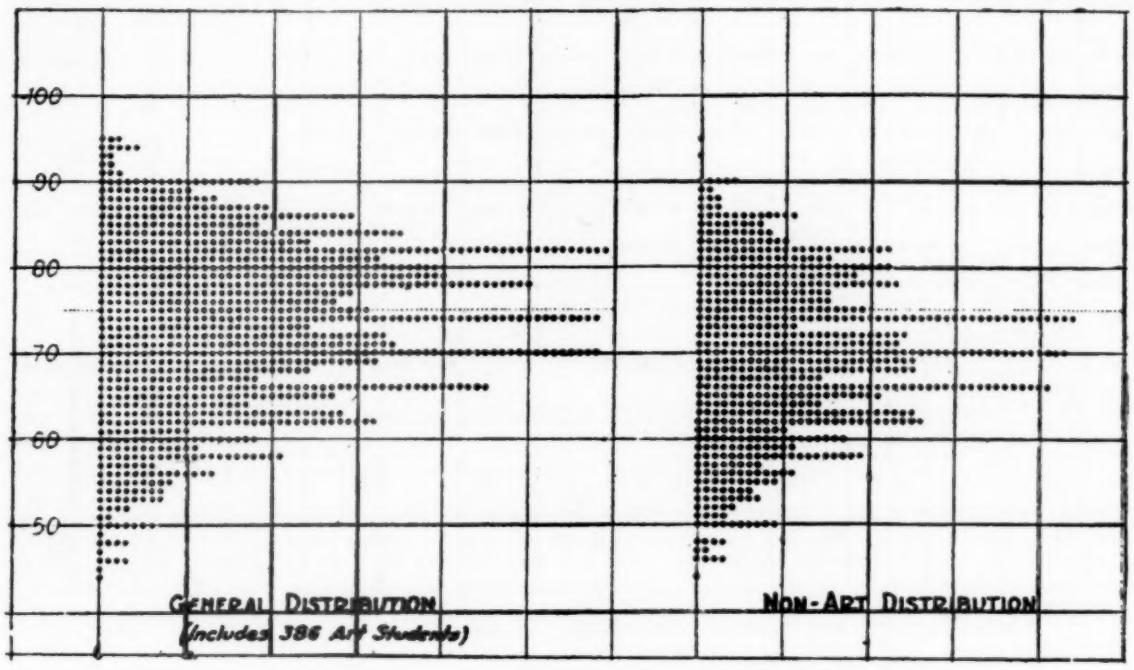

FIG. 8. Distribution of art test scores for 1,081 observers.

and art faculty. The age varied from ten to fifty, but most subjects were between twelve and twenty-two.

The results of this survey were analyzed with the intention of finding (a) the success or non-success of each item in use, (b) the validity of the test, (c) the suitability of each item for different age levels, and (d) data on which to base a final revision of the test. To supplement and aid this program judgments were secured on each item from a " committee " of twenty-five experts, composed of artists, teachers of art, supervisors, directors of art,

[6] The scores in Fig. 8 are adjusted scores obtained after the test was revised to its final form. They are calculated on a basis of per cent correct from a possible total of 125.

one psychologist, and one sculptor. Those test items which were missed 40 per cent or more were discarded immediately; those missed less frequently were considered in the light of the expert judgment, and if that was not consistently definite, other factors were brought in, such as the importance of the principle exemplified by the item, whether or not other test items covered this phase of the principle in any way, or its possibilities for satisfactory reproduction. By such means of elimination fifty-eight items were dropped, leaving 125 superior items for the final test. These were rearranged in a 1—2—4—3 order of difficulty, 1 being the

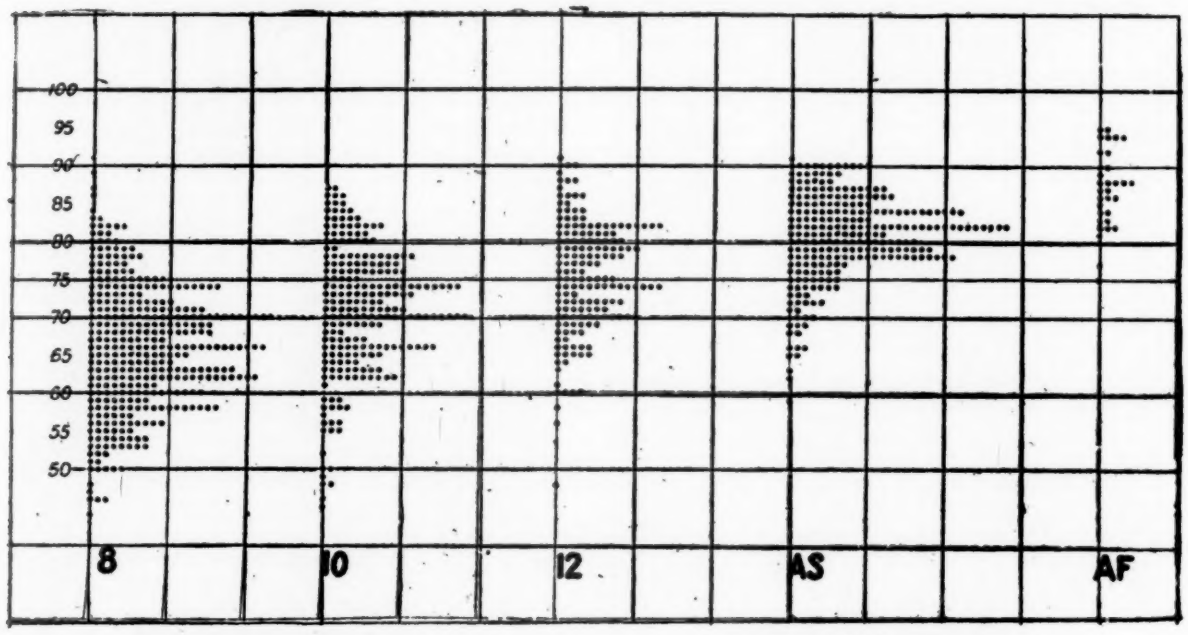

FIG. 9. Comparison of the range of scores for different groups.

quartile of least and 4 of most difficulty. All the scores of the 1,081 subjects were then recalculated by considering only the 125 selected items and reducing this number of correct responses to a hundred per cent basis.

The distribution diagrams illustrated in Figures 8, 9, 10 and 11 present graphically the apparent diagnostic power of the test. Fig. 8 shows the normal-curve distribution of scores in the general non-art population. This is skewed upward in the left-hand distribution which includes the art students. An inspection of Fig. 9 shows that the *range* is very nearly the same in the eighth, tenth and twelfth grades. This fact more or less eliminates the likelihood that the measure tests *learning accomplishment,* in as much as a twelve-year-old non-art eighth grade student can make as high a score as a twenty-two-year-old college senior. The

median scores, however, show an upward tendency (Table I), which may be accounted for either by maturity or by selection.

TABLE I. *Median scores for the different groups to which the art test was given*

8th grade	N = 360	M = 66
10th grade	N = 233	M = 72
12th grade	N = 169	M = 76
Art students	N = 264	M = 82
Art faculty	N = 35	M = 87

The very pronounced skewing in the art student (AS) group again strongly suggests selection. Certainly there is no sanction for assuming a massing of superior general intelligence in this group; in fact most of the evidence at mature levels shows no correlation of a positive kind between art ability and general intelligence. (14, 15)

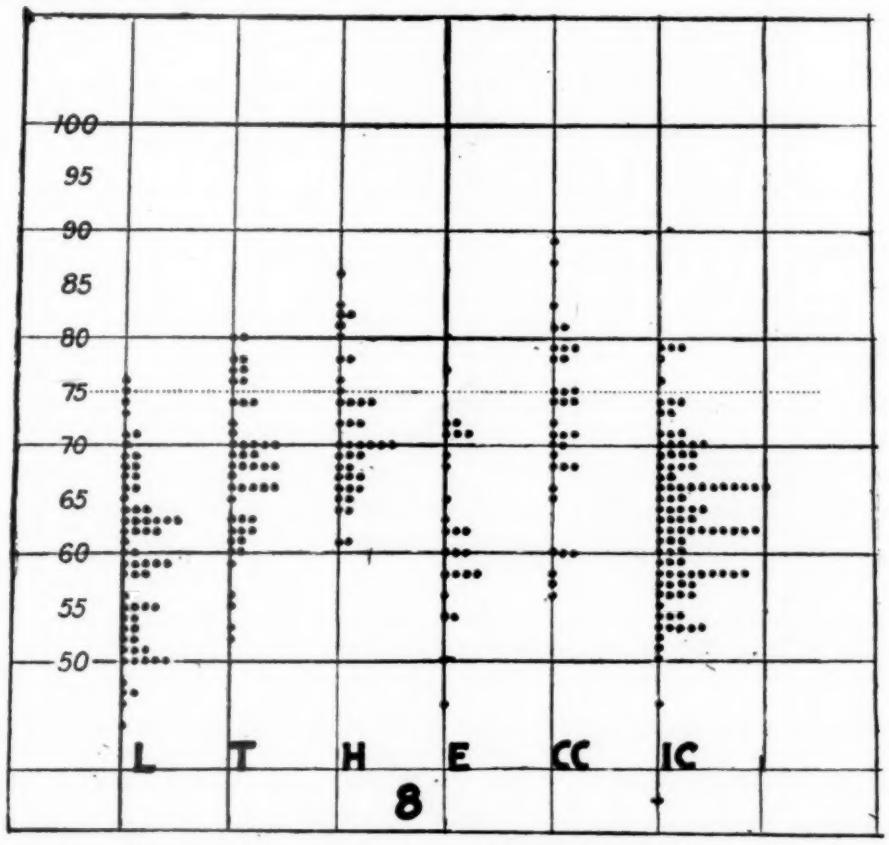

FIG. 10. Comparison of art test scores for various sub-groups.

Fig. 10 shows small group variations within the same scholastic age levels. L, T, and H represent eighth grade groups in the same city. The L class represents a poor section, both economically and socially, made up largely of children of foreign-born parents. T was secured in a slightly less than average section, made up mostly of wage-earners' children. H represents the best type of school child in the city, coming from homes of high standing in which the child had been exposed to art works and

in many cases had traveled widely. Whatever bearing these results may have upon the innateness or acquiredness of art responsiveness or talent of the child must be reserved for further study. CC represents a rather pure American community of probably better than average type; IC, one in which there is a fairly considerable quota of Bohemian children, and E, a village in the east.

In Fig. 11 five urban high schools are shown. C and W represent samples from two high schools in different cities of approximately the same size, each school being the best in its city.

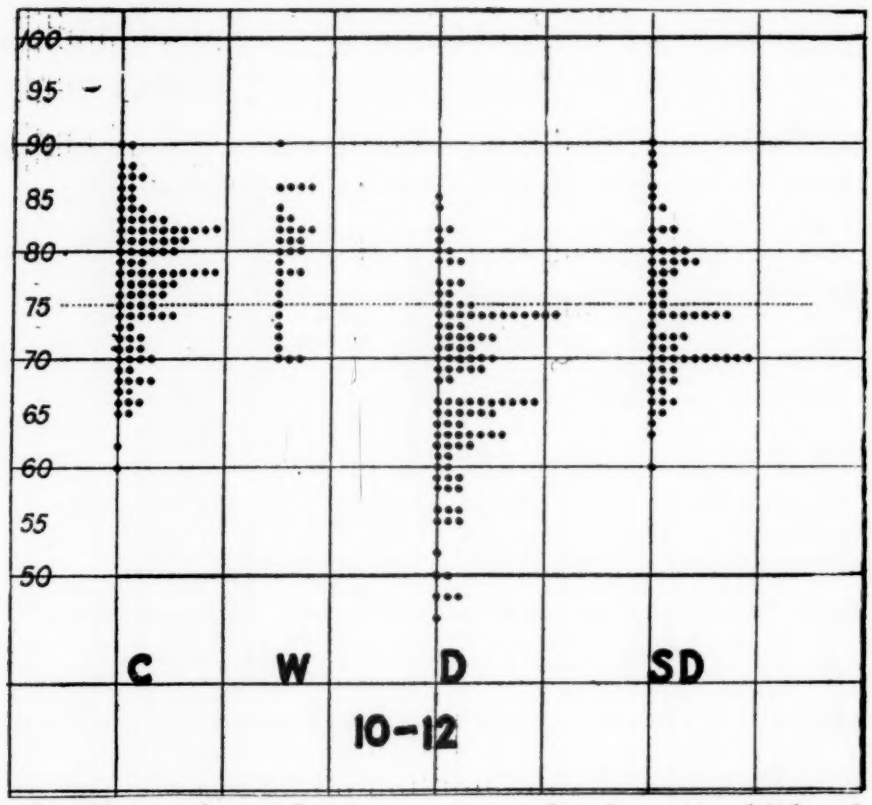

FIG. 11. Comparison of art test scores for four city high schools.

SD is a typical average high school located in the same city as W. It may be assumed that if the number of cases were the same and larger the distribution of C and W would be very similar and that of SD only slightly different. D presents a typical community of 50,000 where there is but one school and hence includes all classes and types of students.

These distributions indicate clearly the dispersion of scores and the probable validity of the test. Considerable work remains to be done in the computation of the coefficient of reliability, correlations with other factors, such as intelligence, and scholastic record, and the standardization and construction of norms for age-, student- and professional-group levels. It is not intended

that this one measure should afford anything more than a general indication of the probability of success or difficulty in an art career. Its function should be considered in connection with all other data bearing upon the individual's fitness, but the position taken is that *aesthetic judgment* as measured by this device is decidedly significant and probably indicative to a very high degree of the extent to which an individual is artistically educable.

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THE FIRST VOCAL VIBRATIONS IN THE ATTACK IN SINGING[1]

By F. A. Stevens and W. R. Miles

Introductory

Thomas Wilson, 1553,(1) vividly describes some of the difficulties experienced by different individuals when they attempt utterance or the attack on the sounds which constitute vocal expression.

> " Musicians in Englade have used, to put gagges in childres mouthes, that thei might pronounce distinctly, but now with the losse & lacke of Musicke, the love also is gone of bringyng up children to speake plainlie. Some there bee that either naturally, or through folie have suche evill voices, and suche lacke of utteraunce, and suche evill gesture, that it muche defaceth all their doynges. One pypes out his woordes so small, through defaulte of hys winde pipe, that ye would

[1] This piece of work is somewhat shriveled from age and neglect but for various reasons I desire to contribute it to this particular volume. No account of it has been published previously. Objective studies on the attack in singing are very few. I undertook this work the next year, 1914, after securing my Ph.D. degree in Psychology under Professor Seashore. It was a coöperative study with my first major student in psychology, Mr. Floyd Alonzo Stevens (since deceased), at Wesleyan University, Middletown, Connecticut, where I was substituting for a year in the absence of Professor Raymond Dodge.

Mr. Stevens was born November 4, 1889, in Jersey City, New Jersey. He prepared for college at the Ridgewood (New Jersey) High School. He was a member of the Commons Club at Wesleyan and received the B.A. degree from that institution in June, 1914. When in the last year of a graduate course for the degree of doctor of philosophy at Columbia University, New York, he entered the Columbia Ambulance Corps and was killed on the field while serving with his unit, June 12, 1918. (*Wesleyan University Bulletin*, May, 1919, XIII, No. 1, 20–21.) Stevens was an enthusiastic, faithful worker.

Our work was made possible by the presence, in the Wesleyan Psychological Laboratory, of apparatus developed and made ready to use by Professor Raymond Dodge who at the time was conducting research at the Nutrition Laboratory (Boston) of the Carnegie Institution at Washington. We are greatly indebted to Professor Dodge for the opportunity afforded of making use of his microscope recorder, falling-plate camera, special timing device, and other equipment essential for the research. W. R. M.

> thinke he whisteled. An other is hoarse in hys throte, that a man would thinke he came latelie from scouring of harnes. . . . An other gapes to fetche winde at every thirde woorde. . . . Some grunts like a hogge. Some cackles like a henne, or a Jacke Dawe. . . . Some whines like a Pigge. Some suppes their woordes up, as a poore man does his potage. Some noddes their hedde at every sentence. An other winkes with one iye, and some with both. . . . Some swelles in the face, and filles their chekes full of winde, as though thet would blowe out the woordes. Some settes forthe their lippes, twoo inches good beyonde their teeth. . . . There are a thousande suche faultes emong men, . . ." Fol. 112.

Wilson's complete inventory of faults and difficulties, too lengthy to reproduce here in its entirety, emphasizes the complexity of the coördination by which the activity of the voice is initiated.

While the general problem is old, in its modern form, it has been divided into the question of initiating a tone and secondly of sustaining tone. We are to consider the former. "The commencement of a note in singing is termed its attack."(2) The word is not a very fortunate one as it suggests jumping at, pouncing upon, grabbing, striking, etc., and is thus likely to be interpreted by the student as calling for vigorous or jerky action. The initiation of a tone in ordinary singing or speaking is, in the nature of things, a rather quickly occurring event. This makes it difficult of introspection and also tends to thwart analysis which may be attempted by some critical auditor. In the second place the start of the tone represents an abrupt transition from one kind of sensory cue, namely a kinaesthetic experience from muscles of respiration and from different portions of the larynx, to another, which is auditory in character. Striking a tone is a kind of leap in the dark. The singer or speaker as a preparatory stage has a clear or maybe only fragmentary mental representation of a particular place in vocal pitch, loudness, and quality which he wishes to reach at the moment. The ear, that is, hearing, is commonly recognized as the competent and exact controller

of the voice, just as the eye, or sight, for most practical purposes, serves as the avenue for directing the coördinations of the hand. But the ear cannot directly exercise its function of fine control until after vocalization has actually started. Any regulation must then be delayed from the inception of the tone by a temporal duration equal to one reaction-time. Although the singer himself could be expected to be prompt in this matter, it goes without saying that his reaction-time must be of about the same order of magnitude as that of the auditors who are listening. Therefore if he is to achieve a true, unwavering and beautiful result it is essential that he initiate his tone satisfactorily and avoid making noticeable adjustments in the note at later stages. Just how this "gap" beween laryngeal tension and the auditory phase of articulation is bridged in the experience of the singer is not very clear. When the eye leaps with a saccadic movement to a new point of fixation, this point may already have been seen in peripheral vision. If the place to be reached is not a definite point and so not sharply defined in attention, as is the case in consecutive reading, the eye will simply move a short distance and stop and seeing will take place without any further preliminaries.(3) On the other hand if a very specific point is motivating the eye movement, then, as a rule, the fixation will not fall directly on that point as a result of the first quick shift of the eyes. The first movement will come to an end with the eye a little short of the desired point. After a duration equal to one visual reaction-time, during which interval the observer becomes aware of his visual position with reference to his real objective, a second shift, "corrective movement"(4) is used to bring fixation to the precise point aimed at. There is really a kind of mental gap in this motor-visual scheme, for the retina is not capable of resolving detail during the moment of eye movement, and so the adjustment is consummated during a moment of quasi-blindness. Similarly a gap as regards absolute consecutive control of movement and end result is well known to exist at the moment of batting at a swift ball. Here again a difficulty arises because the event is too rapid for the eye properly to direct action.

In attacking a tone one cannot, as in golf, literally make several

false swings and then the real drive. There is practically nothing to do but vocalize and have the first attempt count, hoping that it will be a fair hit and that if a little off, the threshold of pitch discrimination in the auditors may take up the error. When vocalizations occur in fairly rapid succession each may benefit from the preceding trial and so the direction and control through the ear is in a way cumulative. The immediacy of previous vocalization experience, at least for most people, is very important in making them certain in their attack. Indeed this is the most practical way to narrow the " gap " that we have been discussing. The obverse of this is seen when a person goes for several hours without vocalization; he is then usually very uncertain and much surprised at his own next utterance by the sound and pitch of his voice.[1]

Mott (5) in 1910 describes the control of attack as primarily confined to loudness and duration. He says, " We are not conscious of any kinaesthetic (sense of movement) guiding sensations from the laryngeal muscles, but we are of the muscles of the tongue, lips, and jaw in the production of articulate sounds. It is remarkable that there are hardly any sensory nerve endings in the vocal cords and muscles of the larynx, consequently it is not surprising to find that the ear is the guiding sense for correct modulation of the loudness and pitch of the speaking as well as the singing voice. . . . The instrument is under the control of the will as regards the production of the notes in loudness and duration, but not so as regards pitch; for without the untaught instinctive sense of the mental perception of musical sounds correct intonation cannot be obtained by any effort of the will. The untaught ability of correct appreciation of variations in the pitch of notes and the memorizing and producing of the same vocally are termed a musical ear." (p. 39)

This physiological and psychological state of affairs described by Mott must obviously be accepted. Its truth is attested by the vocalizations of those who are deaf and in the individual differ-

[1] To Dr. Paul Roth I am indebted for the information that if a person takes two breaths of hydrogen and then tries to attack a given tone he finds to his astonishment that his voice is now much higher than he had expected.

ences of voices which we hear. Given a fair measure of this untaught ability which enables one vocally to approximate tones with fair success, there are three generally recognized (2, 6) ways of attacking a tone. (a) The vocal cords may be approximated and tightened at the same moment that the muscles of expiration are put in action; this is supposed to be the proper method and has sometimes been called "slide of the glottis." This synergistic action of the muscles of the larynx and of respiration is concordant with most acts of voluntary performance; the contributing sets of muscles act synchronously rather than consecutively. (b) When the muscles of the larynx are brought into action first, expiration must force air through what is at the start, a complete obstruction, the closed glottis. The attack in this case is after the manner of a full blown cough or sneeze. As a result there is a noise which precedes the tone. This is called stroke of the glottis, or "click" and is objectionable for obvious reasons. (c) Expiration may be started before the cords are approximated with the result that just as they come into vibration the aspirate is produced. Singing the vowels would in this case result in a ha ho syllable series as if the individual were trying to sing while at the same time engaging in very strenuous muscular labor. Breathing is fundamentally for metabolic rather than for musical purposes. But here is another of the generous streaks of Nature, that the air tides may be time and governed by a rhythm that is foreign to that of the vital processes. Or shall we say that the corpuscles uncomplaining wait for their oxygen while the vocal cords play with the air. Corpuscles will only behave in this way, however, if there is not much business demand, which is to say, that the best vocal music requires that the singer stand still and engage in little or no muscular exercise aside from that which directly concerns the voice, and vocalization.

Problem and Method

Our study confines itself to an investigation of changes in pitch of the voice and concerns the incipient period in tone production covering the first 0.5 second of vocalization. Miles (7) had given only incidental notice to the attack in a study on the

accuracy of simple pitch singing made by use of the Seashore tonoscope.(8) This visual stroboscopic instrument was designed for measuring the continuance of tones and was therefore not suited for observing the initiation and any rapid fluctuations made during the course of the tone; permanent graphic records are desirable here. Klünder (8), 1879, used for this purpose two phonautographs recording simultaneously on smoked paper. One registered the organ tone and the other the vibrations of the voice. The two records were side by side which facilitated comparison. Cameron (9) used a specially designed and quite permanent tambour which he made from the shell of a bell-shaped telephone receiver. The magnets were taken out leaving a cavity for air vibrations behind the membrane which was of mica. Movements of this membrane actuated a small lever system. A funnel-shaped mouthpiece was connected by a rubber tube to the end of the telephone receiver where the wire is ordinarily led in and subjects sang thus directly into a receiver. The recording was on a long belt of smoked paper which passed between two drums fifteen feet apart.

Berlage (10) about the same year, 1907, studied singing by the use of two Marey capsules covered with rubber membranes stretched over them and the recording was by means of a bristle writing on smoked paper. The rubber tubes connecting the recording capsules with the mouthpiece or receiving chamber were not long and extended through the partition from the sound-proof room to the one adjoining where the recording apparatus was set up. The apparatus used by Sokolowski (11) consisted of a combination of well known units, the Einthoven string-galvanometer and the Weiss phonoscope. Organ tones acted on the galvanometer and the voice tones on the phonoscope, both being recorded side by side on a photographic strip carried by a Blix-Sandstrom kymograph.

Just after we had completed the gathering of our data, a study was published by Kerppola and Walle (12). This was carried out at the Physiological Institute at the University of Helsingfors and made use of Frank's (13) heart sound capsules, connected with open funnels for receiving the tones and registering on

photographic surface. Salomonson (14) has used the oscillograph for the photographic registration of voice curves. In all such records of voice tones it is desirable to make use of the lightest possible lever system, in the first place in order that the apparatus may have very slight inertia at the time of coming into action, and in the second place that it should be practically devoid of overshooting and of natural vibratory period.

We were fortunate in being able to have at our disposal the Dodge microscope recorder (15) which met all the demands of our research. This device, so far as we know, has not been illustrated in any of Dodge's papers nor has it been described in any detail. This seems to us unfortunate, for the clever scheme which Dodge has here originated is deserving of extended use. Our verbal description must be regarded as only tentative and a poor substitute for one which perhaps Professor Dodge may give some time in the future.

The most ordinary microscope with single objective and simple stage will serve as the basis for building up the Dodge recorder. A brass plate about one-fourth inch in thickness, the same size as the microscope stage is pierced in the center with a hole approximately 1 cm. in diameter. From this hole to the edge of the plate two grooves are milled at right angles to each other and a third groove extends from the center to the corner of the plate diagonally opposite the angle of the other two grooves. A brass collar about 1.5 cm. in diameter and 2 cm. long is attached to one side of the plate so that its center corresponds with the end of one of the shorter grooves. A brass tube which snugly fits this collar has a rubber membrane attached to one end in the manner of a Marey tambour. At a position not quite midway of this membrane a small silk fiber with a tiny bit of paper attached to the end is drawn through as an extension from the membrane. This fiber passes through the slot adjoining the brass collar, crosses the opening in the middle of the plate and extends down the diagonal slot toward the corner of the plate where it is secured to a small bit of rubber thread, stretched to a slight degree of tension. Now to the center of the silk fiber, that is at the position where it crosses the opening of the plate a second fiber

is tied to it and led up through the other slot. This last fiber therefore pulls against both the circular membrane and the rubber thread and is fastened to the other end of the brass plate by a bit of wax. When air strikes the circular membrane the silk fiber moves back and forth in a longitudinal manner because of its state of tension between the two bits of rubber. Therefore the fiber that has been tied to this one is given a lateral motion. The plate is clamped to the stage of the microscope. The objective is focused upon this second fiber which when projected shows as a shadow and any vibration of the circular membrane produces lateral vibrations of this shadow. A beam from an arc lamp was focused on the thread of the recorder and the shadow of this thread in the light field passed through the optical system of the microscope, which was placed in horizontal position, and was projected on the open slit of a Dodge falling-plate camera (16). The distance from the arc lamp to the camera was approximately 9 feet and the optical magnification was about 150. The records were taken directly on strips of bromide paper $2\frac{1}{2} \times 7$ inches. The camera speed was such that the 7 inches of recording surface passed by the slit in about 1 second. The timing was in 1/100 and 1/10 seconds by interrupting the light with vibrating shutters.

When singing to make the records which form the basis of this study observers stood with posture normal for singing except that they held the tube with the open mouthpiece in front of their lips. Attention was given to making the conditions as natural and comfortable as possible. The individuals were kept alert and in all cases reported on the tone produced, stating whether it met their expectations. The signal to start each tone was given by the experimenter saying " one, two," and instead of saying " three " the plate was released with a click which constituted the real signal to sing. This is a mechanical substitute for the prelude of a few notes on the piano preceding the first efforts of the soloist. Each observer was of course allowed some practice before beginning the series. A group of 36 records were taken on each man (see Table I). These were divided into sub-groups which had to do with humming, open singing, amount of breath in the lungs at the time of singing, loud intensity singing,

singing to the accompaniment of a tuning fork, and singing two vowels, one immediately after the other as smoothly as possible. There were also trials in the attack of tone when singing intervals and finally efforts to vary the attack making it differ from what, according to the introspection, the subject thought was normal for him.

TABLE I. *Order of observations and the divisions into sub-groups* [1]

Sub-group	Tones sung in order from left to right	No. of tonal attacks
I. Humming.....	High, medium, low, low, medium, high.	6
II. Open singing of "ah".....	High, medium, low, low, medium, high.	6
III. Amount of breath, singing "ah" [2]..	Normal, full, almost empty (repeated three times).....	9
IV. Loud singing of "ah".....	Very loud, very loud, very loud.....	3
V. Singing of "ah" from fork.....	After fork, after fork.....	2
VI. Attack through change of vowel, from fork	From fork; "oo" (in fool) to "ah," "e" (in meet) to "ah" (both repeated).....	4
VII. Attack through singing interval from fork, all as "ah".....	Third, fifth, third, fifth.....	4
VIII. Reversal of method, "ah" from fork.	Trying to come to the tone in an unnatural way, second trial.....	2
		36

[1] In each case, except where the fork is mentioned, the observer himself was the judge of what pitch to sing and selected in accordance with his own register without the use of pitch-pipe or outside standard. From 30–60 seconds always intervened between trials. The manipulation of the camera by E produced these natural breaks.

[2] Each subject was his own judge of whether his lungs were full, normal, or almost empty of breath for singing. Full and empty meant almost the limits and the observer gave a hand signal when he was ready.

In the case of humming the mouthpiece was taken off and a small rubber tube was placed between the lips. In all other records the funnel was used. When records were made with the lungs full or empty the counting for starting the subject was omitted, O, himself, giving a hand signal when he was ready to start. In those cases where a standard tone was initiated, the

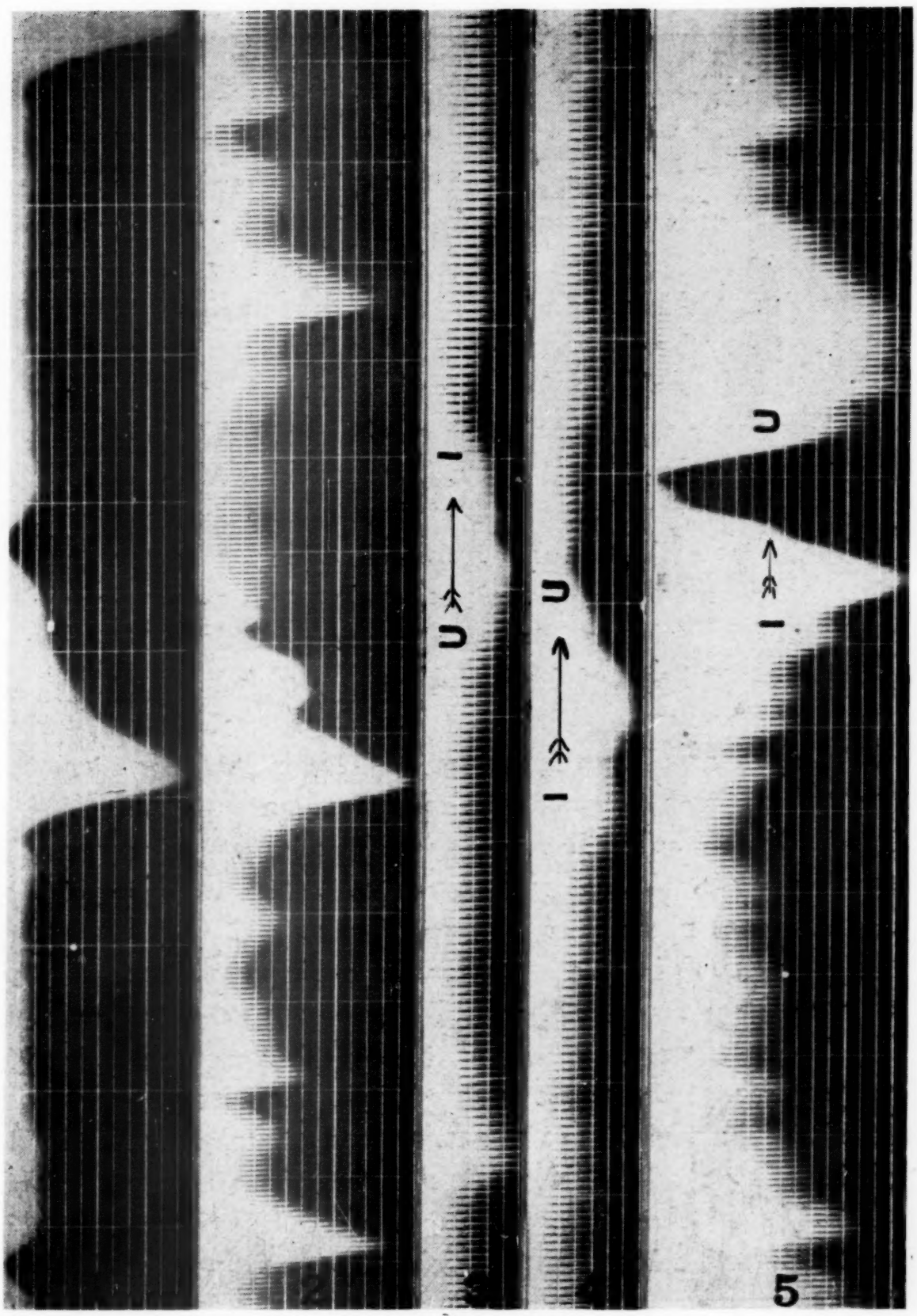

FIGURE I. Illustrative records taken with the Dodge microscope recorder. The white portions show the string's shadow: *1* section of carotid pulse record; *2* pulse record and singing record combined made from holding the receiving funnel on the neck; *3* singing the vowels *u* and *i* consecutively to the same pitch; *4* similarly steady record when singing the vowels *i* and *u*; *5* record for a subject who demonstrated considerable unsteadiness in maintaining a tone and in passing from one vowel to another.

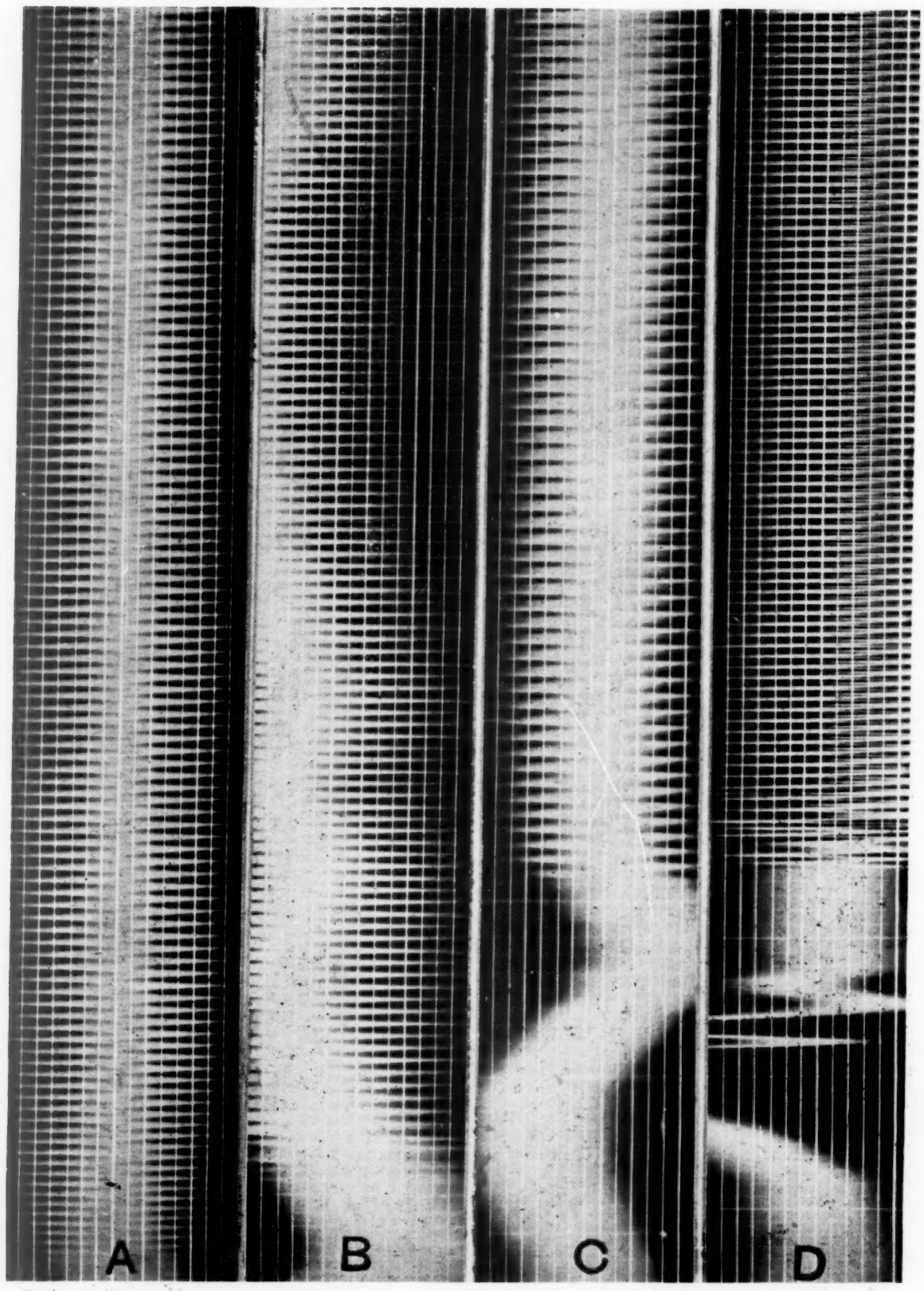

FIGURE II. Four records showing attack of vocal tones: *A* unusually even beginning and continuance of tone; *B* uncertain control of the flow of breath and of the pitch of the voice tone; *C* variations in the air column before the tone starts; *D* an example of unnatural interference between exhalation and laryngeal action at the inception of the tone.

fork was held to O's ear for a short time by a third person and the signal to sing was given to O by the lowering of the fork. In trials on changing the vowels while singing, it was not the intention to study the difference in pitch between the two vowels but merely the fluctuation in pitch on the second vowel. In singing intervals, the object was to ascertain the accuracy with which the tone was taken, it was not a change in pitch in the sense that O sang one tone and then a second; he sang only one tone which was a third or fifth, whichever the case might be, after hearing the fundamental from the fork. In every case except the first six records on each subject, no humming of the tone was allowed and observers were cautioned to watch themselves particularly in this matter, so as to insure the records showing a genuine attack. The precaution was also stressed, in instructing observers, in order that humming and open singing might be compared. Before taking the last two records in the schedule each observer was asked how he pictured himself attacking a tone. Two men said they dropped on the tone as from above, these individuals were then asked to reverse their regular method of attack and try to come from below, that is to mentally reach up to the tone. The other eight men claimed they came to the tone from below, hence the instruction to them was that they try to attack from above.

All the observers (ten in number) were men and interested in vocal singing. Subjects C and F were college professors, the former a semi-professional singer. The others were undergraduates of whom A, B, G, and I may be fairly classed as semi-professionals. By this term we mean that they had taken considerable training in voice and that they frequently sang in public. The last four mentioned men were among the best singers in the college glee club. A, D, F, G, H, I, and J were basses; B, C, and E were tenors.

Illustrative records, typical for this study, are shown in Figures I and II. In Figure I, five records have been trimmed to economize space and are mounted side by side. The white portion of each record represents the moving shadow of the recorder thread. The records are all to be interpreted from the bottom

upward. The thin vertical lines which enable us to directly count off the amplitude of the thread's vibrations are made on the records by fine, evenly spaced, wires which are placed as a part of the camera slit. The horizontal lines represent time. The interval between the stronger lines is 0.1 second. The time lines marking off 0.01 second show only faintly. In the records illustrated the speed is not the same in all cases. This must not be understood as the fault of the camera for the different speeds were used on purpose. Record 1 shows the carotid pulse. The funnel was simply rested over the artery at the neck and held by hand with fairly even pressure. The record will give the reader an idea of the sensitivity of the recorder. In Record 2 the camera rate was made more slow, the funnel was held against the neck as in 1, but here the subject sang two vowels, one after the other, and the voice vibrations show as well as if the funnel were in front of the mouth. Records 3 and 4 are unusually good examples of voice control, when O changes from *u* to *i* and from *i* to *u* as he sings. Record 5 is for a subject who demonstrates considerable fluctuation in his breath control not only as he holds one note but also as he seeks to change it into another vowel sound. In Figure II, Record A shows exceedingly even control as compared with B. Something intermediate between these is the more normal performance. Records C and D show the action of the air column preliminary to the production of tone; D in particular is an example of faulty method in attack.

Results and Discussion

From the ten observers completing the routine outlined there resulted 360 records. A total of ten of these were found to be illegible; we think this is a very low rate of photographic mortality. All the legible records were carefully counted with the aid of magnifying lenses and the results were tabulated for each singer separately. The pitch frequency shown during the first tenth of a second was taken as the standard from which to compare the tone during the next tenth second, and this in turn was made the standard of comparison for the third tenth second and so on. The first five tenth second sections were counted indi-

vidually to the fraction of a vibration, as nearly as this latter could be done on a spatial basis. For example, observer B in the first high note hummed gave 38, 41, 39, 39, and 38.5 v.d. for the five tenth second sections starting with the very first of the tone. Described approximately he started to hum at *g,* shifted almost to *a,* then dropped back to *g* sharp; he thus varied through a range amounting to more than a whole step. From the tables that give the direct vibration counts for the observers we derive tables showing the vibration change in pitch from section to section. The rate or vibration value found for Period I (first 0.1 sec.) is compared with that for II and II is compared with III and so on. This comparison results in four difference values for each tone sung. To continue our example from the results for B, these differences are +3, —2, ±0, and —0.5 v.d. In our derived tables for individuals, which unfortunately like the original tables are too many to print, the differences are all given in terms of vibration frequency. The values range from —3 through +5 v.d. If these seem small it must be remembered that they have a time base of only 0.1 sec. and multiplying them by 10, which we must do to make them conform to our ordinary mode of speaking of the pitch of notes, gives us values that are very far above the pitch discrimination threshold for normal ears. By far the majority of the values in Periods II and III are plus and not larger than 1 v.d.

Even though we cannot present the full individual results a trustworthy impression of them can be gotten from Table II. In the column at the left the different tests in the experimental routine are specified in the order given. To the right of this are four groups of three columns each referring to Periods II, III, IV and V, each compared with its preceding period only. For humming high tones, in 74 per cent of the records measured, Period II showed a higher pitch than I, there was a fall in pitch in 26 per cent and it happened there were no records showing no change. When the III is compared with II there were 53 per cent plus changes, 47 per cent minus and 0 per cent no change. Comparing IV with III we find +39, —44 and =17 per cent, and about these same values are found when V is compared with IV.

Inspecting this table as a whole we find that for II plus signs decidedly predominate, there are about twice as many plus as minus values, and the column for = shows rather small values. When the subjects attack the tone " from below " we have, as perhaps could be expected, +100 per cent. Singing the " third " above the fork, previously heard, gives +80 per cent. Singing the fork tone, which was 128 v.d., after hearing it but not in unison with it, gave +72 per cent, while singing the observer's own medium tone without any standard having been given shows +63 per cent. For the III there is still a generally rising pitch as shown by the plus values being somewhat more frequent than

TABLE II. *The percentages of vocal tones that showed pitch raised (+), lowered (—), or not changed (=) in the consecutive intervals of 0.1 second.*

Singing test	Periods of 0.1 second of tone											
	II			III			IV			V		
I	+	—	=	+	—	=	+	—	=	+	—	=
Humming: high	74	26	0	53	47	0	39	44	17	40	46	14
medium	60	25	15	40	45	15	21	47	32	62	19	19
low	20	60	20	50	30	20	39	39	22	25	50	25
average[1]	51	37	12	48	41	11	33	43	24	42	38	20
II												
Singing: high	55	25	20	60	30	10	58	37	05	41	41	18
medium	63	32	05	52	26	22	37	37	26	56	25	19
low	55	35	10	65	20	15	35	50	15	53	20	27
average[1]	58	31	11	59	25	16	43	41	16	50	29	21
III												
Breath: normal	58	27	15	45	45	10	41	24	35	44	37	19
full	43	50	07	40	47	13	63	17	20	32	48	20
" empty "	46	35	19	45	52	03	66	21	13	35	48	17
IV												
Loud singing	57	33	10	40	40	20	33	40	27	45	38	17
V												
From fork	72	17	11	39	39	22	33	33	34	27	40	33
VI												
Change of vowel:												
" oo "–" ah "	47	32	21	58	31	11	32	47	21	35	29	36
" e " –" ah "	50	50	0	47	42	11	39	39	22	50	25	25
VII												
Musical interval:												
Third above	80	05	15	40	50	10	75	15	10	24	58	18
Fifth above	50	35	15	65	35	0	40	50	10	47	42	11
VIII												
Reversed method:												
" dropped "	25	62	13	56	24	20	50	37	13	50	36	14
" from under "	100	0	0	25	25	50	100	0	0	25	50	25

[1] Average for high, medium, and low the three values given above in each case.

those with the minus. In Period IV there is almost an even balancing between plus and minus per cents, and in V the number of minus values is in excess of the plus per cents. Table II, as representing the general frequency of distribution of the singing results, indicates consistency for most of the tests, and since we have found by carefully going over the full results that individual subjects cannot be clearly divided into classes or subgroups, it appears that there is no violent distortion produced by giving all the results in terms of averages for the ten men. Individual men are found to be plus in one test and minus in another in what seems a random order, much as the scatter in results produced by an coördinating muscle group aiming at some kind of target. However, for all subjects taken together, there is no getting around the general predominance of plus values in Periods II and III and the plus averages are not produced by a few subjects going strong plus.

The results in terms of averages for the different tests in our experiment are presented in Table III, arranged after the same manner as the former table. From these averages it is clear that the general tendency is for the voice to rise continuously in pitch for about 0.3 sec. after the vocal cords begin vibrating, then it tends to hold steady for a short interval or begins to fall slightly. We believe the general result when the voice attacks a tone may be justly represented by Figure III, N. The predominance of plus results on the left side of Table III and the changing to minus at the right side is conspicuous. There are nineteen entries in each column. In II there are 17 plus and 2 minus, in III 15 plus and 4 minus, in IV 11 plus and 8 minus, while in column V there are 7 plus and 12 minus. Our results confirm those of Cameron (9) which he summarized in the following: "In the great majority of cases there is a rise in pitch quite extraordinary as compared with difference in pitch elsewhere in the tone. This rise is so general a feature of the beginning of a tone, as shown by these and numerous other records made in connection with this investigation, as to warrant the statement that it is a universal tendency." A tuning fork may be activated by suddenly exerting stress on the prongs through striking the fork or by quickly with-

drawing a wedge that has been inserted between the prongs. The fork thus energized will start vibrating at full amplitude and at its normal pitch. The vocal cords are not normally started in this manner, that is, with such a result. Of course, we are depending on the microscope recorder to tell us what is happening in reference to the activity of the cords, we are not actually photographing them as they come into motion. But basing our judgment on the records which we have it seems reasonable to believe that the cords come into operation promptly but not instantaneously. They do not attain full vibratory amplitude or rate immediately. Records 2, 3, 4, and 5 of Figure I are instructive in this regard. They show in a clear manner the changes in amplitude as the cords come into action. The full amplitude is apparently reached within 7 or 8 v.d. Careful measurement

TABLE III. *Average results for attack in the various tests given in terms of vibration change per time unit of 0.1 second from the first initiation of the vocal tone.*

Singing test	Periods of 0.1 second of tone			
	II	III	IV	V
I				
Humming: high	+.75	+.24	+.01	—.02
medium	+.36	—.11	—.21	+.19
low	—.28	+.01	—.00	—.31
average	+.27	+.04	—.06	—.04
II				
Singing: high	+.58	+.10	+.25	—.10
medium	+.50	+.47	—.22	+.17
low	+.31	+.22	—.14	+.26
average	+.46	+.26	—.03	+.11
III				
Breath: normal	+.23	—.13	+.06	+.02
full	+.02	+.01	+.29	—.11
"empty"	+.22	+.01	+.16	—.03
IV				
Loud singing	+.26	—.01	—.08	—.01
V				
From fork	+.37	+.19	+.02	—.12
VI				
Change of vowel:				
"oo"–"ah"	+.08	+.18	+.16	—.14
"e" –"ah"	+.17	+.00	+.04	+.03
VII				
Musical interval:				
Third above	+.79	—.02	+.23	—.15
Fifth above	+.22	+.31	—.02	—.00
VIII				
Reverse method:				
"dropped"	—.37	+.04	+.21	+.06
"from under"	+.43	+.03	+.23	—.06

would show that the rate also is going through a change which is usually in the direction of increasing frequency. In the records of Figure II, that is, A, B, C, and D, the amplitude comes to its full value rather more promptly than in the records of Figure I, probably because here the singer is not changing the muscles of articulation from one vowel to another but is able to give them proper form from the very start. Both situations, that is, when the singer comes out squarely on one tone and again when he shifts from one vowel to another must be considered in forming our ideas of the first vibrations of the vocal cords in the attack in singing. Time is probably the important factor here and if the pitch of the voice is low it will reach its full value in a few vibrations, whereas if it is high, the actual number of vibrations elapsing before full amplitude and proper pitch are attained will be larger. According to pitch range the vocal cords in starting the singing of a note may reach full amplitude and rate in from 3 to 10 vibrations.

In Table III there is no place where the average value for the difference between successive tenth second intervals reaches 1 v.d. although this amount is approached in humming the high note and in singing the "third." When we take into consideration the actual vibration rates counted we find that the changes I to II, II to III, etc., amount to 2 or 3 per cent in some cases but mostly are less than 2 per cent which in these terms gives the impression of a fair degree of accuracy, but we know that in pure pitch discrimination, at middle range, a good ear can sense a change of ¼ per cent between two closely succeeding instrumental tones.

There is some evidence that the voice, on the basis of the observer's first auditory impressions or from the kinaesthesis of the organs of articulation, is voluntarily and actively adjusted even within this half-second period. When humming a high tone it is made progressively higher after it is started. The opposite occurred at the time of humming a low tone, see Figure III, M. So that the effort to get a low tone, low in O's register, is continued in some manner after the tone is initiated, with the average result that the tone is indeed further lowered. In the singing

of intervals, see Figure III, W, especially the "third" above the fork, which O has listened to previously, something of this same active directing is shown, the tone is quickly brought up to what seems right and is practically held at that level.

The general results for humming a tone and for open singing show that the attack is less certain or steady from the start in the case of humming. We may surmise that the specific coördination of parting the lips and of bringing them and the tongue into a certain position for vocalization is favorable for bringing about a more specific coördination in the larynx. The result is that the attack for high, medium and low tones in open singing tends to conform to a certain pattern, see Figure III, O. We may judge from this that humming is not as accurate as is open singing. There is a general impression among vocalists that humming is the more accurate. This impression is probably accounted for by the fact that the singer may, quietly and unheard by others, hum a tone and on the basis of this experience immediately attack with confidence in open singing. The fact is not that humming has been more accurate but that he has been able to avail himself of immediately preceding singing experience, which as pointed out earlier, is the best general regulator for the voice.

The efficiency of attack when the voice has just previously been in action is shown in Table III where the observers changed from "oo" to "ah" and from "e" to "ah", see also Figure III, V. If these results are compared with those for humming or for the simplest open singing it will be seen that the attack with vowel change was more certain and unwavering throughout the measure period.

If in place of hearing one's own voice the preceding auditory experience has consisted in listening to the tuning fork and imagining one's self singing, an experience that has been called "silent singing," see Berlage (10), it is found that the result is not as good as with the "vowel change." The fork used was 128 v.d. and it is seen in Table III that the results are closely the same as those found for the low tone in open singing, which as sung by men approximated this same pitch level. This is a significant result that the attack was not made for certain by

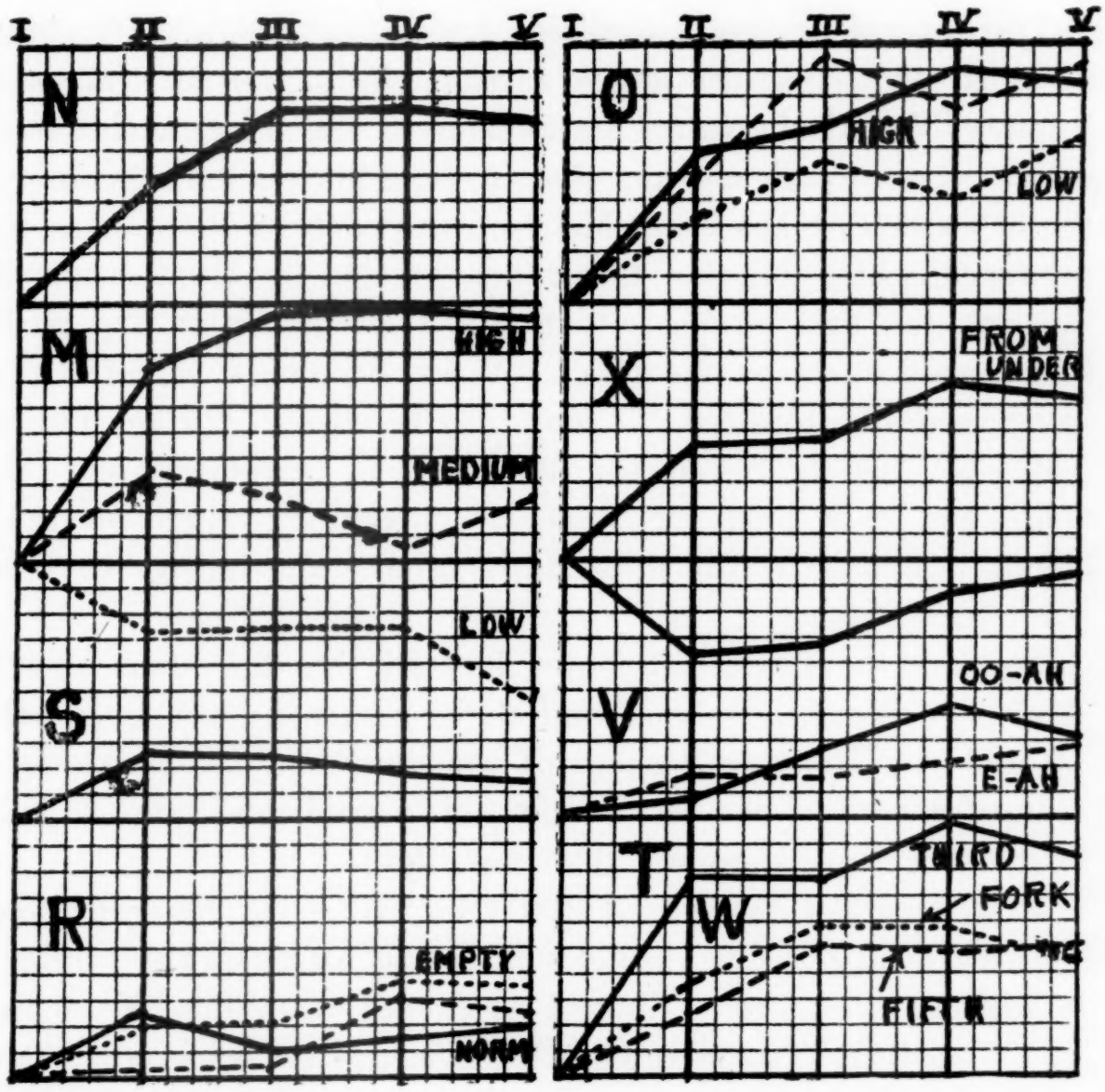

FIGURE III. Diagrammatic representation of the results in attacking tones in the various tests: *N* normal performance of the voice; *M* results for humming high, medium and low tones; *O* open singing of high, medium and low tones; *R* singing with full, natural or "empty" breath; *S* loud or strong singing; *T* singing a tuning fork tone after the instrument has ceased sounding; *V* attack through change of vowel; *W* attack of intervals "third" and "fifth" having previously listened to the tuning fork as standard; *X* results from reversing the mode of attack.

the use of the tuning fork over the situation when the singer entirely conceived and initiated his own tone, and that in neither was attack as exact as when observers preceded from one vowel to another on subjectively the same pitch. Obviously it is not just auditory experience that adjusts the voice in its attack but such experience synchronously coupled with the kinaesthetic experience of vocalization.

The amount of breath available for singing seems to produce no great change in the attack results. With normal, full and "empty" breath the values are medium or low for our table as a whole. It is worth noticing that in the other tests of the series the O's attention has been chiefly on the pitch of the tone to be produced, while here the instructions stressed the breath control. We can say that placing attention not altogether on the pitch had a good effect on the attack. When the lungs were full the attack was not impaired. It may only be chance, but we find in Table III that the results for full breath in Periods II, and III, +.02 and +.01, are the smallest consecutive values in these columns, indicating the most unchanging tone during the first 0.3 sec. of singing.

The loud tones were not poorer in attack than the others. They show a moderate rise in II and slight minus differences in III, IV and V. The three periods of consecutive minus constitute a feature unique in our test results. The loud tone came to full pitch value more promptly than the others.

It is generally recognized that the "fifth" is easier to sing than the "third." Our results indicate that attack of the "third" is with less certainty. Singers apparently with the aid of the ear, "reach up" for a suitable pitch value, not being so certain of it prior to vocalization as they are of many other tonal situations. "Reaching up" and "dropping down on" are phrases which singers use in describing their mode or imagery associated with the attack experience. When Os were instructed to "drop on" the pitch the result was minus in Period II and slight plus in III, IV and V, but not enough to bring the pitch up to the value of the first tenth second, see Figure III, X. The "dropping" is thus not limited to the incipient interval but, as in the case where the effort was to hum a low tone, operates beyond the actual initiation of the tone. The two observers who were instructed to attack "from under" consistently gave plus values for Period II but the results are not much different from our other general averages.

Our experiments have not settled why it is that singers and speakers show the *"thousande suche faultes"* cited by the

rhetorician Thomas Wilson. We have in fact worked on only one little twig of the tree which, largely through the stimulus of Professor Seashore, we may confidently expect will finally be studied in every root and branch.

Summary

1. In several investigations the accuracy of singing in unison with or immediately following the tone of some instrument, commonly the organ, has been studied. Rarely has the vocal attack in singing been studied through the use of objective records.

2. Singing records were made by the aid of the Dodge microscope recorder and photographic registration. Ten men, semi-professional and amateur singers, were the observers. Vibrations were counted for five consecutive tenth second intervals after the tone was started and these five intervals are compared to give the course of the tone for the first 0.5 sec.

3. The human voice in attacking a tone raises its pitch from 1 to 3 per cent (0.5 to 5.0 v.d.) within the first 1/5 sec. of singing. Later the rise is more slight and by the end of 0.5 sec. there may be a slight tendency to lower the pitch.

4. Humming in itself is less certain as a mode of vocal attack than is open singing.

5. In singing major intervals, the "fifth" is begun more certainly than is the "third."

6. So far as evenness of tone is concerned the attack is not made more certain by having just listened to an instrument (tuning fork). The singer is more likely to achieve a specific average vibration frequency by having heard the note on the instrument but he will not necessarily produce his tone more smoothly from the moment of its start.

7. Singing on a full breath does not interfere with the objective evenness of the attack but rather seems to improve it.

8. The best guarantee of success in attack, as to pitch and evenness of result, is to have had immediately preceding vocal experience at about the same level in pitch range. This is realized in the singing of different vowels consecutively to the same note.

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